Naval Facilities Engineering Command Pacific
JBPHH HI

Final

Record of Decision
Pearl Harbor Sediment

JOINT BASE PEARL HARBOR-HICKAM OAHU HI

JBPHH PEARL HARBOR HI SITE 19

PHNC National Priorities List Site

September 2018

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ACRONYMS AND ABBREVIATIONS

µg/kg	microgram per kilogram
AC	activated carbon
AE	assessment endpoint
AFB	Air Force Base
AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
AVS-SEM	acid volatile sulfide-simultaneously extracted metals
BERA	baseline ecological risk assessment
BMP	best management practice
BOD	basis of design
BSAF	biota-sediment accumulation factor
bswi	below the sediment-water interface
CAD	confined aquatic disposal
CCH	City and County of Honolulu
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm	centimeter
cm/y	centimeter per year
CO_2	carbon dioxide
COC	chemical of concern
COPC	chemical of potential concern
CSM	conceptual site model
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DOH	Department of Health, State of Hawaii
DON	Department of the Navy
DU	decision unit
EC	engineering control
EMAP	Environmental Monitoring and Assessment Program
ENR	enhanced natural recovery
EPA	Environmental Protection Agency, United States
EPC	exposure point concentration
FFA	Federal Facility Agreement
FS	feasibility study
ft	foot or feet
FUDS	Formerly Used Defense Site
GRA	general response action
HAR	Hawaii Administrative Rules
HCZMP	Hawaii Coastal Zone Management Program
HECO	Hawaiian Electric Company
HHRA	human health risk assessment
HI	hazard index
HIA	Honolulu International Airport
HQ	hazard quotient
HRS	Hawaii Revised Statutes

IC	institutional control
IDW	investigation-derived waste
in/y	inch per year
IR	Installation Restoration
JBPHH	Joint Base Pearl Harbor-Hickam
LOAEL	lowest-observed-adverse-effect level
LUC	land use control
MCPP	2-(2-methyl-4-chlorophenoxy) propionic acid
mg/kg	milligrams per kilogram
mgd	million gallons per day
MNR	monitored natural recovery
NAR	no active remediation
NAVFAC	Naval Facilities Engineering Command
NAVSTA	Naval Station
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
no.	number
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPV	net present value
O&M	operations and maintenance
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzo-p-furan
PHNC	Pearl Harbor Naval Complex
PHNWR	Pearl Harbor National Wildlife Refuge
PP	proposed plan
PRG	preliminary remediation goal
PRISM	Pathway Ranking for In-place Sediment Management
RA	remedial action
RAB	Restoration Advisory Board
RACR	Remedial Action Completion Report
RAL	remedial action level
RAO	remedial action objective
RBTC	risk-based threshold concentration
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RME	reasonable maximum exposure
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act
SI	site inspection
SITE	Superfund Innovative Technologies Evaluation
SOODMDS	South Oahu Ocean Dredged Material Disposal Site
SPAWAR	Space and Naval Warfare Systems Command
SUBASE	Submarine Base
SWAC	surface area–weighted average concentration

TBC	to be considered
TEQ	toxicity equivalency quotient
TOC	total organic carbon
TSCA	Toxic Substances Control Act
U.S.	United States
U.S.C.	United States Code
USACE	United States Army Corps of Engineers
WP	work plan
ww	wet weight
yd^3	cubic yard

1. Declaration

1.1 SITE NAME AND LOCATION

The United States (U.S.) Department of the Navy (DON or the Navy) has prepared this record of decision (ROD) for the Pearl Harbor Sediment site, located at Joint Base Pearl Harbor-Hickam (JBPHH), Oahu, Hawaii (Figure 1-1). The site is part of the Pearl Harbor Naval Complex (PHNC) National Priorities List (NPL) site. The NPL identifies priorities among known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The site is identified on the NPL as U.S. Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation, and Liability Information System Number (no.) HI4170090076.

1.2 STATEMENT OF BASIS AND PURPOSE

This ROD presents the selected remedy for the Pearl Harbor Sediment site, located at JBPHH, Oahu, Hawaii. The remedy was chosen by DON and EPA in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] 300) and the Office of the President of the U.S. Executive Order 12580, *Superfund Implementation*. This decision is based on the Administrative Record (AR) file for the site.

The State of Hawaii Department of Health (DOH) concurs with the selected remedy.

1.3 ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health, welfare, or the environment from actual or threatened releases of hazardous substances into the environment.

1.4 DESCRIPTION OF SELECTED REMEDY

The Pearl Harbor Sediment site is comprised of ten distinct areas of the harbor, identified as Decision Units (DUs) (Figure 1-2). The Remedial Investigation (RI) (DOH 2013) at the site identified six of the DUs for remediation to address potentially unacceptable risks to human or ecological receptors exposed to contamination associated with the sediments (Figure 1-3):

- DU SE-1 (Southeast Loch)
- DU N-2 (Oscar 1 and 2 Piers Shoreline)
- DU N-3 (Off Ford Island Landfill and Camel Refurbishing Area)
- DU N-4 (Bishop Point)
- DU E-2 (Off Waiau Power Plant)
- DU E-3 (Aiea Bay)

Remedial alternatives were developed and evaluated for each of the six remediation DUs based on the unique physical, chemical, and biological characteristics of each DU (Figure 1-3). Some of the remedial technologies (e.g., enhanced natural recovery [ENR], in-place treatment with activated carbon [AC] amendment, and monitored natural recovery [MNR]) were selected to take advantage of ongoing natural recovery processes. ENR involves placement of a thin layer of clean material (such as sand) to accelerate the rate of natural recovery. In-place treatment with AC amendment involves placement of a thin layer of activated carbon to limit the bioavailability of contaminants from uptake by ecological receptors. It is expected that remediation will be performed either concurrently or sequentially for all DUs, and, therefore, will include a mix of remedial construction activities for dredging, ENR, AC amendment, and MNR. Remediation will be coordinated with regular maintenance dredging of the harbor's navigation channels and berths to optimize the efficiency of the remedial efforts while minimizing interference with naval activities in the harbor.

The remedy selected for each DU addresses human health risks associated with the consumption of harbor fish and shellfish by reducing concentrations of chemicals of concern (COCs) in surface sediments to protective levels. It also addresses ecological risks to bottomfish and waterbirds by reducing concentrations of COCs in surface sediments to protective levels. Long-term fish tissue monitoring will be included as part of the remediation effort to provide an additional measure for evaluating the effectiveness of the remedy.

Remedial actions for the six DUs designated for active remediation were selected based on the results of a feasibility study (FS) (DON 2015). The FS developed remedial alternatives consisting of various combinations of 13 different remedial technologies, and evaluated each alternative against the nine NCP criteria, as discussed in Section 2.10.1, to identify the most appropriate alternative for remedial action in each DU. The remedial footprints established in the FS (DON 2015) for the selected remedial alternatives are presented in Figure 1-4.

Based on additional pre-design data and information acquired during a 2017 Navy field investigation conducted to support development of the basis of design (BOD) and following consultation with the EPA and DOH, the Navy agreed that the new data and information provided by the BOD investigation will be used to refine the extent of areas of remedy implementation (i.e., implementation areas) within the remedial footprints established in the FS. Remedy implementation areas for the selected remedial alternatives have been refined based on the 2017 BOD data for DUs SE-1, N-2, N-4, and E-2. As a conservative measure, the Navy will implement MNR for areas within the remediation footprint that no longer require active remediation based on the 2017 BOD data. A detailed discussion on refined remedy implementation areas is presented in Section 2.12.3 and Attachment F of this ROD. Figure 1-5 presents the selected remedial alternatives, including the refined remedy implementation within the remediation footprint. The resulting changes in the remediation cost based on the refined implementation areas are documented in this ROD to provide the most accurate and up-to-date estimates of remediation costs. Table 1-1 presents the sediment areas and volumes expected to be remediated based on the refined implementation area (Figure 1-5) established by incorporating additional data collected in 2017 and the estimated costs to implement the remedy. EPA's guidance to address pre-ROD changes indicates that "significant changes involve either (1) selecting as the remedy an RI/FS alternative other than the preferred alternative identified in the Proposed Plan; or (2) modifying a component of the previously identified preferred alternative." Therefore, the changes in the selected remedy from what was presented in the proposed plan (PP) do not constitute a significant change. The selected remedy is the same as the remedy that was identified in the PP, and there is no modification to any of the components to the previously identified preferred alternative. The refined area of remedy implementation will still lead to the achievement of the remedial action objectives (RAOs) as was presented in the PP.

The remaining four DUs at the site have been identified for No Active Remediation (NAR) (Figure 1-3):

- DU N-1 (Majority of Navigation Channel)
- DU W-1 (West Loch)
- DU M-1 (Middle Loch)
- DU E-1 (Majority of East Loch)

The Remedial Investigation (RI) Addendum results confirmed that these DUs pose no unacceptable risk to human health or the environment (DON 2013); however, the Navy will perform at least one round of sediment and fish tissue sampling and analysis. This round of sampling would confirm that the NAR DUs continue to pose no unacceptable risk to human or ecological receptors, and that COC levels in surface sediments are stable or decreasing as expected based on the concentration trends indicated by the existing sediment and fish tissue data (DON 2013, 2015). If sediment and fish tissue concentrations are not stable or decreasing as expected, additional sediment and fish tissue monitoring for the NAR DUs may be performed during the Five-Year Review for the site.

1.5 STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action (unless justified by a waiver), is cost-effective, and uses permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable.

The remedy will leave some relatively low level contaminants in place without undergoing treatment because ENR and in-place AC treatment will be limited to sediments with moderate COC concentrations in DU SE-1, DU N-2, DU N-3, and DU N-4, and dredged material will not be treated prior to disposal. Therefore, the remedy does not satisfy the statutory preference for treatment as a principal element, but the remedy does include placement of AC amendment which limits the mobility of COCs and their toxicity to receptors. Additionally, extensive treatment is not necessary to reduce risks to human and ecological receptors to acceptable levels based on the current and future intended use of the site. Remedial alternatives that would require treatment of contaminated sediments throughout the harbor are cost prohibitive. MNR will be implemented for areas within DUs SE-1, N-2, and E-2 that have relatively low level contamination.

Because the selected remedy will result in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted every five years following initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. After the initial five-year review, additional reviews will repeat every five years so long as future uses remain restricted.

1.6 DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD (Section 2): Additional information can be found in the AR file for the site.

- COCs and their respective concentrations (Section 2.5.3)
- Baseline risk represented by the COCs (Section 2.7)
- Cleanup levels established for COCs and the basis for these levels (Section 2.12.5)
- How source materials constituting principal threats will be addressed (Section 2.11)
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD (Section 2.6)
- Potential land and groundwater use that will be available at the site as a result of the selected remedy (Section 2.6)
- Estimated costs, annual operation and maintenance costs, and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (Section 2.12.3)
- Key factors that led to selecting the remedy (Section 2.12.1)

1.7 SIGNATURE AND SUPPORT AGENCY ACCEPTANCE OF SELECTED REMEDY

The Navy and EPA, with DOH concurrence, have selected a combination of focused dredging, ENR, AC amendment treatment, and MNR as the remedy for the six DUs identified for remediation within the Pearl Harbor Sediment site. The remedy is protective of human health and the environment. In accordance with CERCLA requirements, five-year reviews will be necessary to ensure that the selected remedy remains protective of human health and the environment at the Pearl Harbor Sediment site within the PHNC NPL at JBPHH, Oahu, Hawaii.

24 SEP 2018
Date

S. R. King
Captain, CEC, U.S. Navy
Executive Officer

26 SEP 2018
Date

Angeles Herrera
Assistant Director, Federal Facilities and Site Cleanup Branch
Superfund Division, U.S. EPA Region 9

The State of Hawaii DOH concurs with the selected remedy as documented in this ROD.

26 Sep 2018
Date

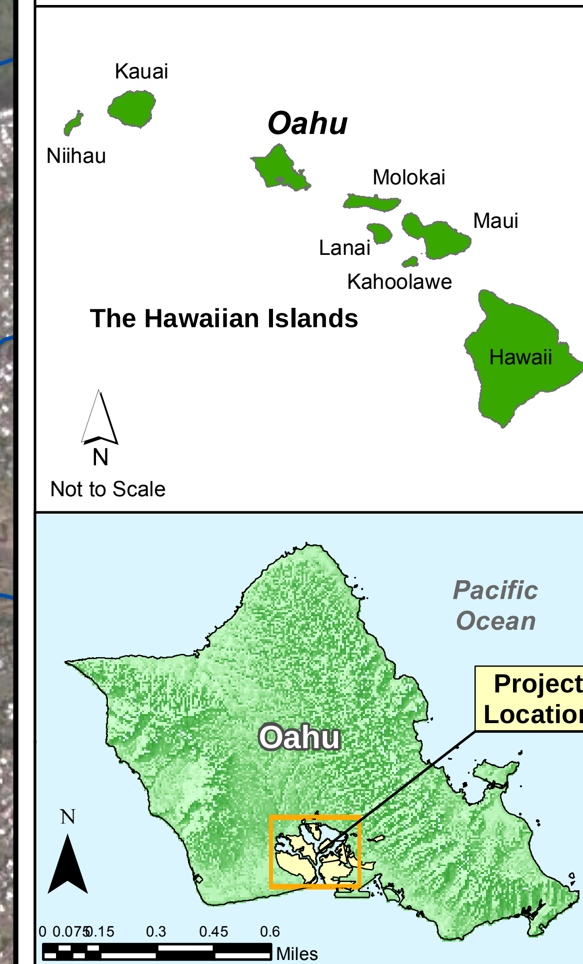
G. Fenix Grange
Program Manager
Hazard Evaluation and Emergency Response Office
State of Hawaii, Department of Health

Table 1-1: Remedial Alternatives Selected for the Six DUs Identified for Active Remediation

DU	Selected Remedial Alternative	Remedial Alternative Description	Rationale
SE-1 (Southeast Loch)	Focused Dredging with ENR, AC, and MNR (achieve PRGs in 20 years)	• Removal of sediments with relatively high COC concentrations (2 acres, 17,000 yd^3) • Placement of thin layer of clean material to enhance natural recovery for sediment with moderate COC concentrations (12.6 acres) • Monitoring of natural recovery for sediment with relatively low COC concentrations (139 acres) • AC amendment treatment in place for selected areas identified for ENR and MNR (11.1 acres) [a] • AC amendment treatment for under-pier areas (8 acres) • Total estimated cost is $31.4 million	• Substantial short-term risk reduction through removal of sediments with high COC concentrations; reduced long-term risk by limiting bioavailability of COCs through the use of AC amendment • Achieve RAOs through natural recovery within reasonable time (20 years) • Relatively cost efficient • Minimized construction-related impacts to the environment, society, and economy
N-2 (Oscar 1 and 2 Piers Shoreline)	ENR with MNR (achieve PRGs in 10 years)	• Placement of thin layer of clean material to enhance natural recovery in sediment areas with moderate COC concentrations (1.6 acres) • AC amendment treatment for sediment with moderate COC concentrations in under-pier areas (0.7 acre) • Monitoring of natural recovery for sediment with relatively low COC concentrations (14.2 acres) • Total estimated cost is $1.9 million	• Readily implementable • Achieve RAOs within a relatively short period (10 years) • Minimal construction-related impacts to the environment, society, and economy
N-3 (Off Ford Island Landfill and Camel Refurbishing Area)	ENR	• Placement of thin layer of clean material to enhance ongoing natural recovery in sediment with moderate COC concentrations (0.6 acre) • Total estimated cost is $270K	• Readily implementable • Achieve RAOs immediately • Minimal construction-related impacts to the environment, society, and economy
N-4 (Bishop Point)	ENR	• Placement of thin layer of clean material to enhance ongoing natural recovery in sediment with moderate COC concentrations (0.7 acre) • Monitoring of natural recovery for sediment with relatively low COC concentrations (1.5 acres) [b] • Total estimated cost is $380K	• Readily implementable • Achieve RAOs within a relatively short period (20 years) • Minimal construction-related impacts to the environment, society, and economy
E-2 (Off Waiau Power Plant)	Focused Dredging with MNR (10 years)	• Removal of sediments with relatively high COC concentrations (1.5 acres, 7,500 yd^3) • Monitoring of natural recovery for sediment with relatively low COC concentrations (7.2 acres) • Total estimated cost is $3.4 million	• Substantial short-term risk reduction through removal of sediments with high COC concentrations • Relatively cost efficient through combined use of active remediation and natural recovery to achieve RAOs in a reasonable time (10 years) • Minimal construction-related impacts to the environment, society, and economy
E-3 (Aiea Bay)	MNR (10 Years)	• Monitoring of natural recovery for sediment with relatively low COC concentrations (73.5 acres) • Total estimated cost is $2.4 million	• Readily implementable • Low cost • No construction-related impacts to the environment, society, and economy

PRG preliminary remediation goal
yd^3 cubic yard
[a] Some ENR and MNR areas are also designated for treatment with AC amendment. These areas are presented in Figure 1-4 and Figure 1-5 as ENR + AC and MNR + AC areas.
[b] Monitoring is implemented to address remnant areas excluded from ENR based on 2017 BOD data.

LOCATION MAP



LEGEND

Site Boundary

Stream

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Acronyms/Abbreviations:
   JBPHH: Joint Base Pearl Harbor-Hickam
   NAVFAC HI: Naval Facilities Engineering Command Hawaii
   PHNWR: Pearl Harbor National Wildlife Refuge

N

0 0.25 0.5 1 Mile

Figure 1-1
Site Location Map
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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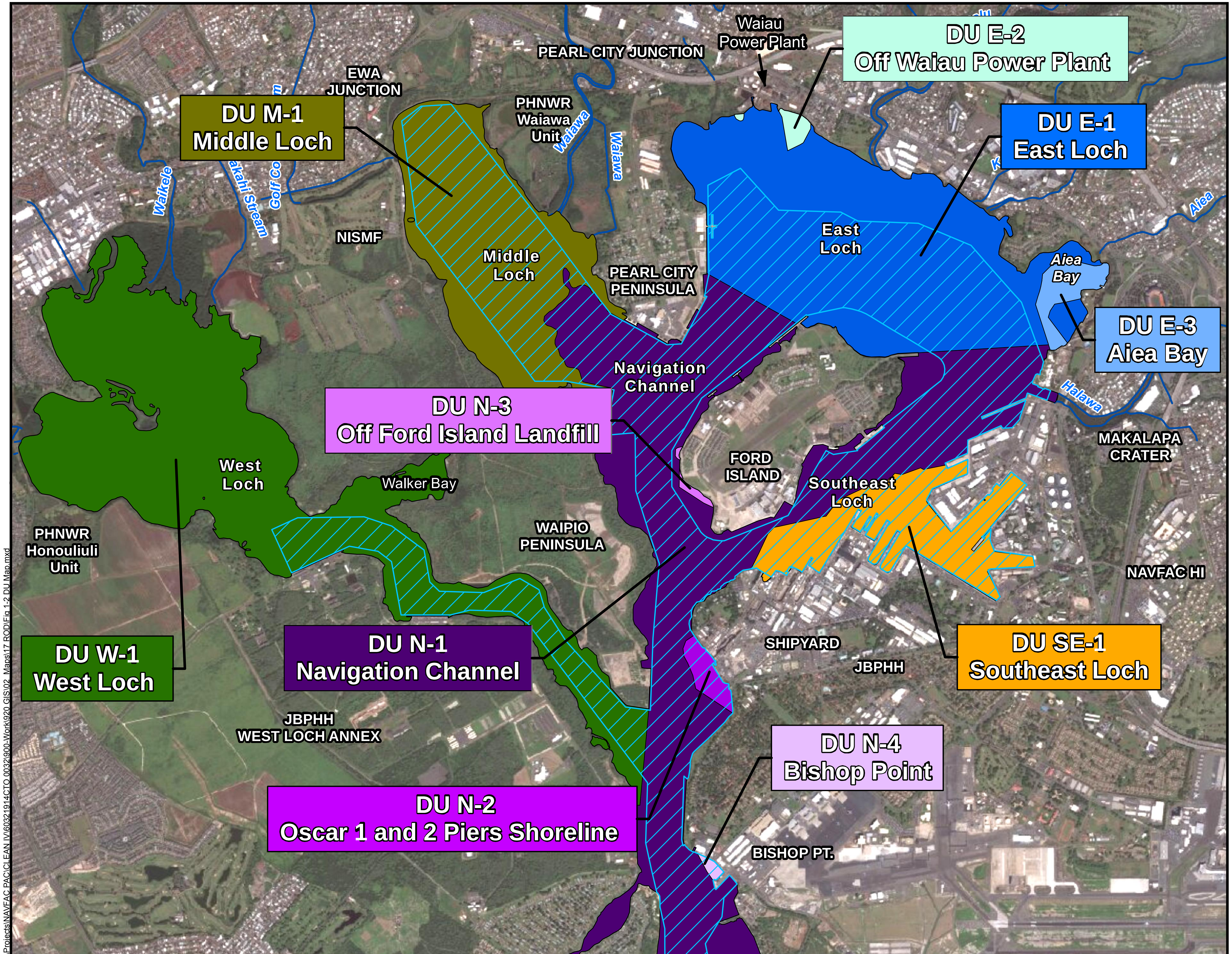
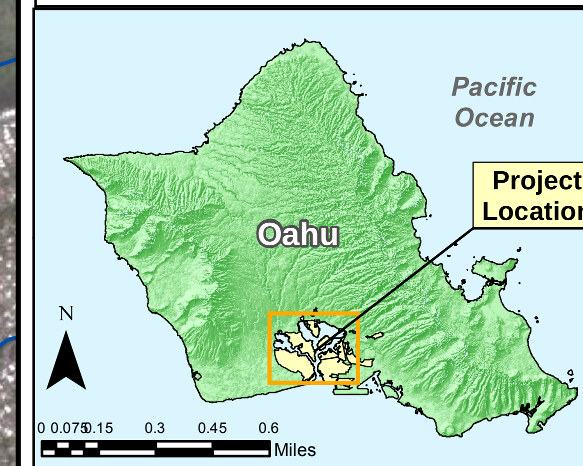


LOCATION MAP



LEGEND

- DU E-1 East Loch
- DU E-2 Off Waiau Power Plant
- DU E-3 Aiea Bay
- DU M-1 Middle Loch
- DU N-1 Navigation Channel
- DU N-2 Oscar 1 and 2 Piers Shoreline
- DU N-3 Off Ford Island Landfill
- DU N-4 Bishop Point
- DU SE-1 Southeast Loch
- DU W-1 West Loch
- Maintenance Dredging Footprint
- Stream

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).

N

0 0.25 0.5 1 Mile

Figure 1-2
Decision Unit Boundaries
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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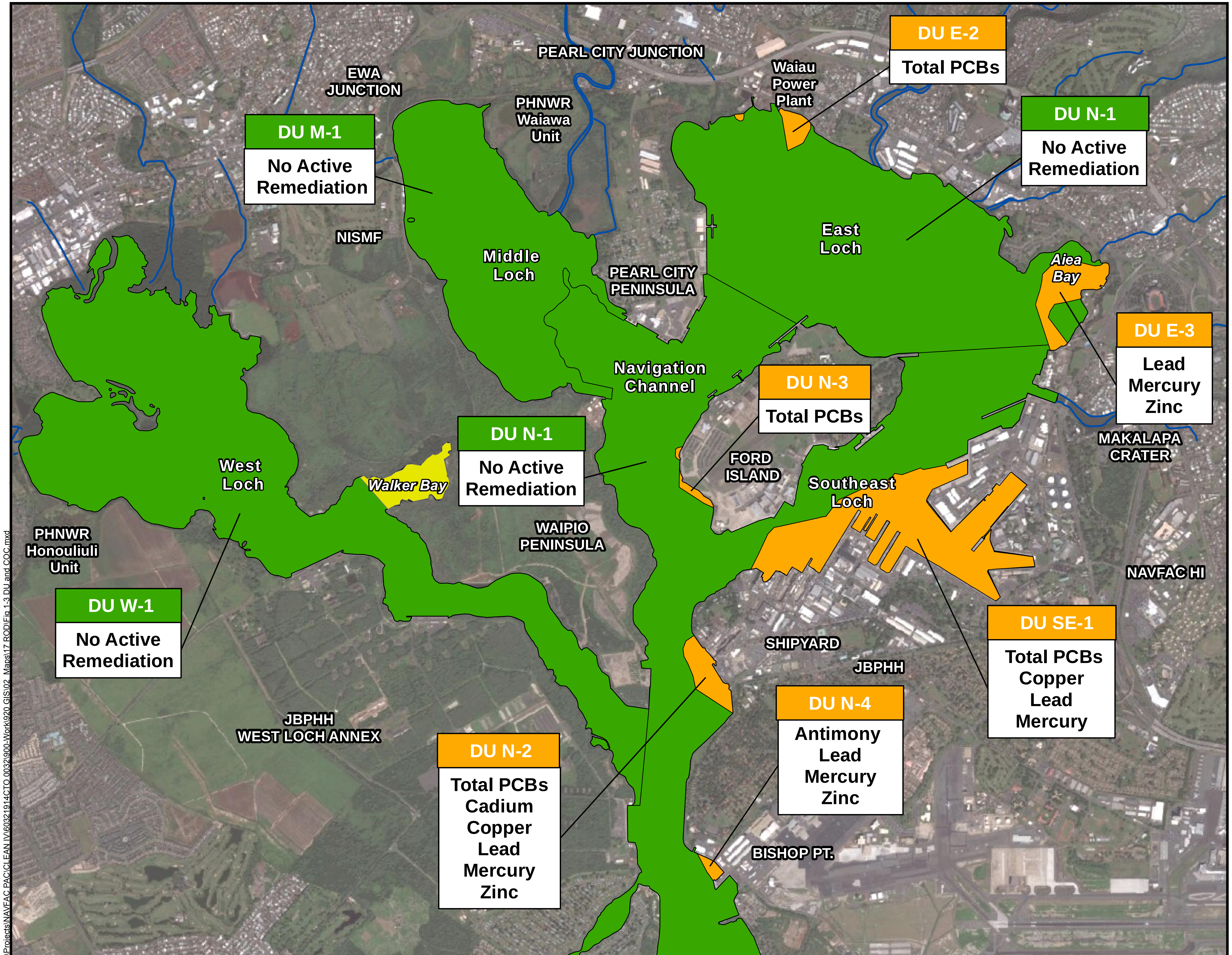

S:\Projects\NAVFAC PAC\CLEAN IV\60321914\CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 1-3 DU and COC.mxd

LEGEND

- Walker Bay - Area to be further evaluated by the Navy as part of the land-based investigation
- DU Identified for Remediation and LTM Fish Monitoring Area
- DU Identified for No Active Remediation
- Stream

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).

N

0 0.25 0.5 1 Mile

Figure 1-3
Areas and COCs Identified For Remediation of Sediment
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

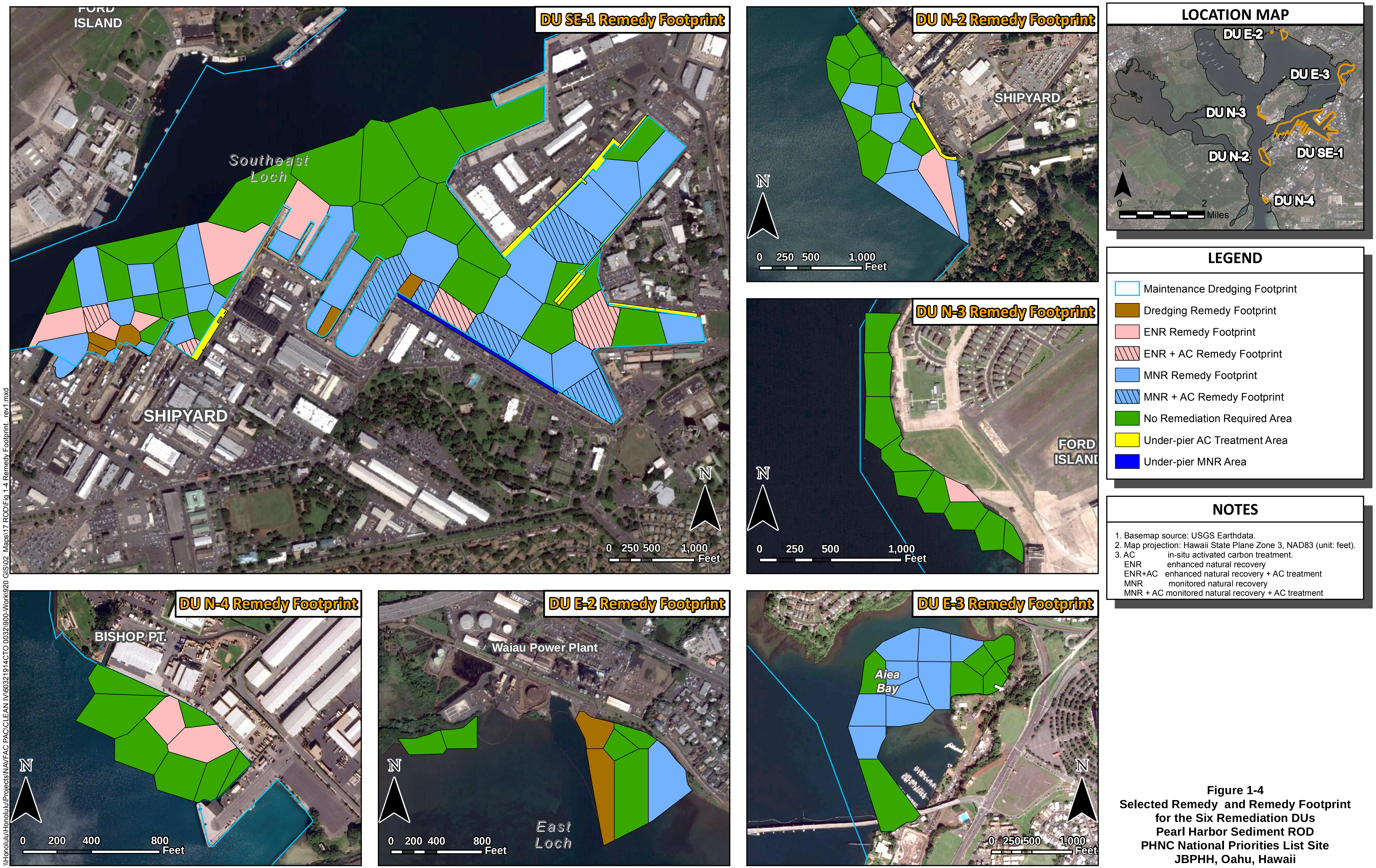

Figure 1-4
Selected Remedy and Remedy Footprint for the Six Remediation DUs
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

\\Honolulu\Honolulu\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 1-4 Remedy Footprint_rev1.mxd

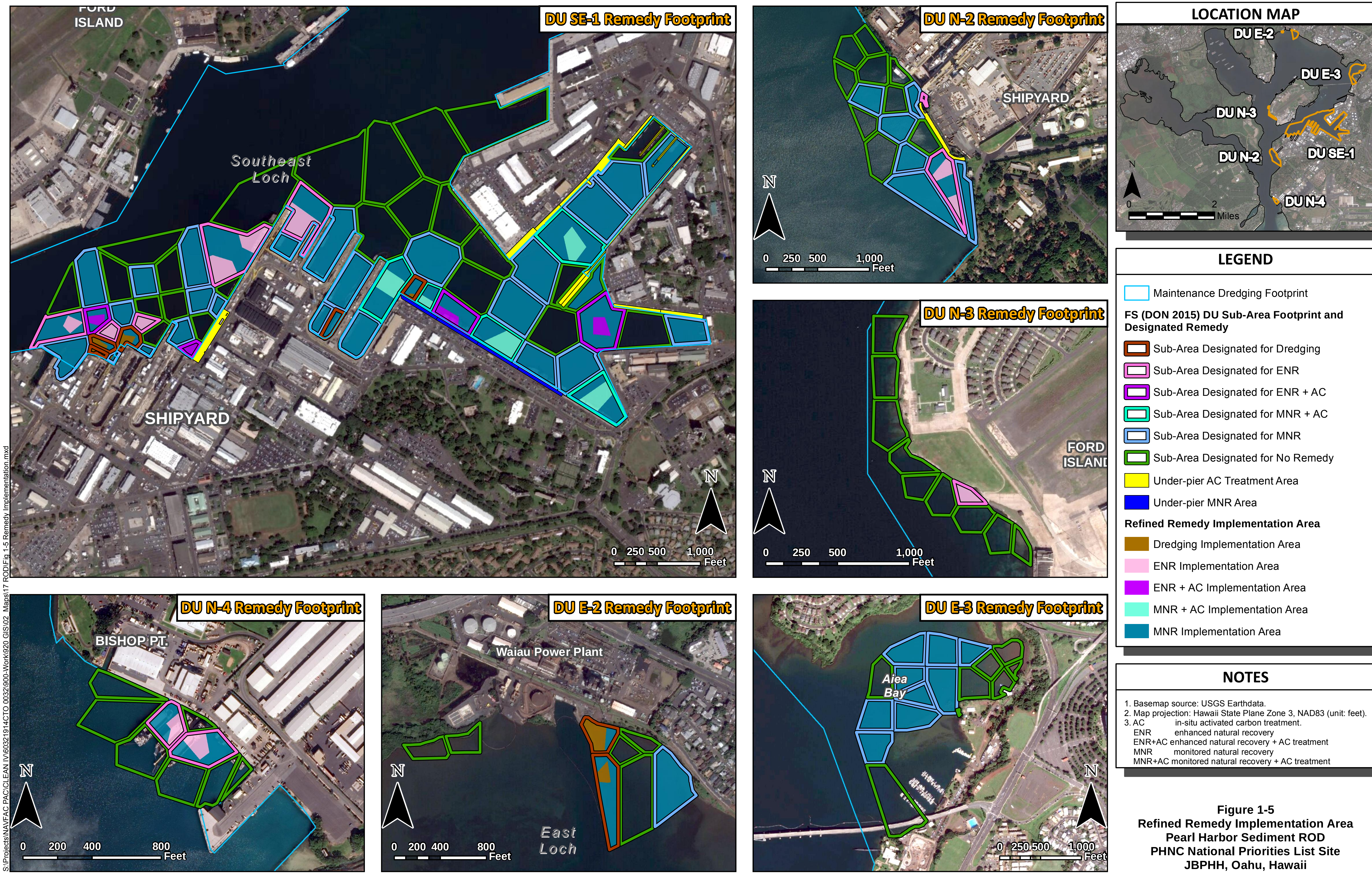

Figure 1-5
Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

2. Decision Summary

This section summarizes site characteristics, potential human health and ecological risks, evaluation of response action alternatives, and the rationale for the decisions that led to selection of the remedy for the Pearl Harbor Sediment site.

2.1 Site Name, Location, and Description

The Pearl Harbor Sediment site is included within JBPHH, Oahu, Hawaii, as shown on Figure 1-1. The site is part of the PHNC, which is identified on the NPL under EPA CERCLA Information System no. HI4170090076. The PHNC, including Pearl Harbor itself, was placed on the NPL by the EPA in October 1992 (PHNC was incorporated into JBPHH in October 2010, but the NPL site remains designated “PHNC”).

The Pearl Harbor Sediment site extends over approximately 5,000 acres of submerged land in the Pearl Harbor estuary, in the south-central portion of Oahu, Hawaii. The harbor is a natural trap, or sink, for sediments and chemicals discharged with surface water runoff from approximately 110 square miles of watershed, or 20 percent of Oahu’s land surface. Although contaminant sources associated with naval activities at the harbor have contributed to the sediment contamination in Pearl Harbor, contaminants released from commercial, industrial, residential, and agricultural sources in the surrounding watershed, and discharged from the tributary streams and storm drains that enter the harbor, have also contributed a broad range of contaminant chemicals to the Pearl Harbor estuary and its associated sediments. The entire site is restricted for Navy use; public access restrictions to the waters of Pearl Harbor severely limit fishing opportunities. Limited fishing at the site is restricted to pole-cast catch-and-release only from selected locations within the harbor. Additionally, the State of Hawaii implemented a Seafood Consumption Advisory (ATSDR 2005) for the entire Pearl Harbor advising the public not to consume seafood from the harbor.

DON is the lead agency for the Pearl Harbor Sediment site, EPA Region 9 is the lead oversight agency, and DOH is a support agency.

2.2 Site History and Enforcement Activities

2.2.1 Site History

The U.S. government obtained sole rights to use the harbor as a port in 1887, and major development of naval facilities at Pearl Harbor began in 1908. Over the last century, extensive dredging and filling operations have altered the shoreline configuration and bathymetry of the harbor to provide navigation channels for large naval ships and construct shoreline facilities to support the Pacific Fleet.

Pearl Harbor is now the homeport for nearly 40 warships, service force vessels and submarines, and is listed as a National Historic Landmark. In October 2010, Naval Station (NAVSTA) Pearl Harbor merged with adjacent Hickam Air Force Base (AFB) into JBPHH. The joint base occupies most land immediately surrounding Pearl Harbor. The Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility (Shipyard) occupy much of Southeast Loch and the surrounding shoreline; other naval facilities are located within and along the shore of the other three lochs, the navigation channel, and Ford Island. The Navy controls all waters and submerged land in Pearl Harbor.

2.2.2 Site Investigations

Pearl Harbor has been the subject of numerous investigations over the last 30 years. Previous environmental investigations at the site are summarized below; further detail is presented in the RI (DON 2007a), RI Addendum (DON 2013), and FS (DON 2015) reports:

- **Initial Assessment Study** [1] (NEESA 1983): This early study by Naval Energy and Environmental Support Activity included assessment of potentially contaminated sediments within Pearl Harbor. The study recommended no further action for Pearl Harbor sediments. EPA Region 9 disagreed with the recommendation.
- **Middle Loch Core Investigation** (Ashwood et al. 1986): An investigation by Oak Ridge National Laboratory of the distribution of lead and other trace metals in Middle Loch sediments assessed whether paint chips from vessels of the U.S. Navy's Inactive Fleet have affected the environmental quality there. The data indicated that historical sewage discharge rather than anti-fouling paint was the major source of trace metal (i.e., lead, copper, zinc) contamination in Middle Loch sediments. The study concluded that lead concentrations in Middle Loch were no greater than those in other estuaries near urban and industrial areas of the United States.
- **Resource Conservation and Recovery Act Facility Assessment** (Kearney 1987): A Resource Conservation and Recovery Act (RCRA) Facility Assessment of the more highly industrialized areas around Pearl Harbor concluded that many assessed sites posed little or no threat to human health and the environment (harbor sediments are the major sink or repository for chemicals transported through pathways to the harbor from these upland activities).
- **Evaluation of Sediment Contamination** (Grovhoug 1992): A review of existing information on Pearl Harbor compiled from previous studies concluded that the environmental risks attributable to contamination of sediment, water, and organisms in Pearl Harbor were moderately low, and risk to human health was low.
- **Environmental Monitoring and Assessment Program (EMAP)** (EPA, n.d.): A 2002 pilot study for the EMAP evaluated analytical data representing surface sediment samples collected at 20 locations in Pearl Harbor (including Southeast Loch, the navigation channel, West Loch, Middle Loch, and East Loch). The data indicated that chromium, copper, mercury, nickel, and selenium concentrations remained at levels exceeding the RI screening criteria. Total polychlorinated biphenyl (PCB), total dichlorodiphenyltrichloroethane, antimony, arsenic, cadmium, lead, silver, and zinc concentrations in sediment decreased within certain areas of Pearl Harbor.
- **Superfund Innovative Technologies Evaluation (SITE)** (2007): As part of their SITE program, the EPA collected 33 sediment cores off the southwest shore of Ford Island Landfill to evaluate PCBs and polychlorinated dibenzo-p-dioxin/-furan (PCDD/PCDF) congeners. The results of the study showed that concentrations of both PCBs and PCDDs/PCDFs in surface and near-surface sediments had decreased since the 1996 RI sampling event (DON 2007a) off the southwest shore of Ford Island Landfill, with PCDD/PCDF toxicity equivalency quotient (TEQ) concentrations well below the Pearl Harbor Sediment RI sediment screening criterion.
- **Pearl Harbor Dredging Activities** (DON 2009, Section 10.6 and Appendix B.4): Chemical data representing dredged material from 11 dredging events in Southeast Loch, the navigation channel, West Loch, and Middle Loch between 1990 and 2006 were screened

[1] Text in blue font identifies where detailed cross-reference site information is available (Attachment A). In the event of any inconsistency between the text in this ROD and the text in any of the cross-reference documents, the text in this ROD will take precedence.

against the Pearl Harbor Sediment RI (DON 2007a) ecological preliminary remediation goals (PRGs) for metals, pesticides, PCBs, and polynuclear aromatic hydrocarbons (PAHs). The chemical concentrations reported for West Loch, Middle Loch, and most navigation channel sediments did not exceed the screening criteria and were classified as suitable for ocean disposal. However, the concentrations reported for Southeast Loch dredging-area sediments exceeded screening criteria for metals and PCBs, and the sediments were classified as unsuitable for ocean disposal.

- **Fish and Benthic Communities** (Smith, Deslarzes, and Brock 2006): A study of the marine community in Pearl Harbor including the entrance channel found that the marine biological communities were generally healthy and that sunken derelict items, hull fragments, and piers provided important habitat for marine communities. The study concluded that the structures should not be removed unless they created a navigational hazard, and that an alien seaweed, *Gracilaria salicornia*, was the most significant threat to aquatic organisms in the harbor and controlling its spread should be considered the most important priority for sustaining and protecting the fishery and benthic invertebrate resources of Pearl Harbor.
- **Pathway Ranking for In-place Sediment Management (PRISM)** (SSC 2006): The PRISM program evaluated contaminant flux rates from marine sediments using a benthic flux sampling device developed by the Navy's Space and Naval Warfare Systems Command (SPAWAR). Tests at Pearl Harbor were conducted at Southeast Loch (off Dry Docks) and Bishop Point. The program evaluated a range of process-based contaminant transport pathways including diffusive, advective, sedimentation, erosion, and biodegradation fluxes to determine which pathway may be dominant. The target analytes selected for the study were metals (aluminum, arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel, silver, tin, zinc) and PAHs. At Southeast Loch, the PRISM pathway analysis found that sediment settling acts as a source for copper and zinc; no other processes are dominant enough to drive recovery for these metals. Potential recovery for nickel in Southeast Loch via settling and diffusion is balanced by a continuing source from advection. At Bishop Point, the study found that deposition of sediments is driving reduction of metal concentrations in the mixed layer. Settling is identified as the significant pathway for recovery for copper and zinc and less significant for nickel, which is supplemented by diffusion. Both of these processes, however, are offset by a continuing source from advection.
- **Pearl Harbor Sediment Remedial Investigation** (DON 2007a): The Pearl Harbor Sediment RI report, based on 1996 sampling, identified the types of chemical contaminants in Pearl Harbor sediment and biota, quantified the chemical concentrations, assessed sediment toxicity, assessed potential risks to human health and the environment associated with the sediments and biota, and evaluated the nature and extent of sediments that may pose unacceptable risk to human health or the environment. The RI report concluded that the following chemicals of potential concern (COPCs) and COPC groups exhibited human health risk above acceptable thresholds for fish and crab consumption, and ecological risk above acceptable thresholds for one or more ecological risk assessment endpoints (AEs):
  - Metals (antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, zinc)
  - PAHs
  - PCBs
  - PCDDs/PCDFs

  - 2-(2-Methyl-4-chlorophenoxy) propionic acid (MCPP, a chlorinated herbicide)
  - 2,4,6-Trinitrotoluene

- **Pearl Harbor Sediment Remedial Investigation Addendum** (DON 2013): The Pearl Harbor Sediment RI Addendum was initiated in 2009 after the EPA requested the Navy to further characterize the nature and extent of contamination in the harbor before proceeding with the FS. The RI Addendum established and evaluated ten distinct areas of the harbor as DUs, and evaluated each DU using a decision process based on multiple lines of evidence supported by the combined RI and RI Addendum data. PRGs based on risk to human health/ecological receptors and site-specific background levels (calculated in the RI) were used as sediment screening criteria to evaluate the nature and extent of contamination in the harbor. The report included the following recommendations:
  - **Further Consideration for Sediments:** The report recommended seven DUs for further consideration of remedial action for sediments contaminated with eight metals, total PCBs, and two chlorinated pesticides. The FS work plan (WP) refined the RI Addendum report recommendations to focus the FS remedial alternative evaluations on the following six DUs for the indicated COPCs, as shown on Figure 1-3:
    - DU SE-1 (Southeast Loch): copper, lead, mercury, total PCBs, dieldrin, total endosulfan
    - DU N-2 (Oscar 1 and 2 Piers Shoreline): cadmium, copper, lead, mercury, zinc, total PCBs, dieldrin
    - DU N-3 (Off Ford Island Landfill and Camel Refurbishing Area): total PCBs, dieldrin
    - DU N-4 (Bishop Point): antimony, lead, mercury, zinc, total endosulfan
    - DU E-2 (Off Waiau Power Plant): total PCBs
    - DU E-3 (Aiea Bay): lead, mercury, silver, zinc
  - **Further Consideration for Long-Term Fish Monitoring:** The report recommended that the FS evaluate the need for long-term fish monitoring for the following areas and COPCs:
    - Shipyard (Southeast Loch): total PCBs
    - Off Bishop Point and the Ford Island Landfill (Navigation Channel): total PCBs
    - Walker Bay (West Loch): PCDDs/PCDFs
    - Off the Waiau Power Plant: total PCBs
    - Aiea Bay (East Loch): total PCBs
    - Oscar 1 and 2 Piers Shoreline: total PCBs

- **Pearl Harbor Sediment Feasibility Study** (DON 2015): An additional investigation was conducted in 2012 as part of the FS to collect data and information to refine the boundaries of sediment contamination (i.e., further consideration of the DU boundaries); supplement the RI and RI Addendum results; update the conceptual site model (CSM) and recommendations for potential source control measures; confirm the conclusions of the ecological and human health risk assessments; and assist in evaluating remedial alternatives for each further-consideration DU (DON 2015). The FS results were used to refine the list of COCs identified for remedial action to six metals (antimony, cadmium, copper, lead, mercury, and zinc) and PCBs. The following six Pearl Harbor Sediment DUs are identified (Figure 1-3) for active remediation of sediments for the indicated COCs:

- DU SE-1 (Southeast Loch): copper, lead, mercury, total PCBs
- DU N-2 (Oscar 1 and 2 Piers Shoreline): cadmium, copper, lead, mercury, zinc, total PCBs
- DU N-3 (Off Ford Island Landfill and Camel Refurbishing Area): total PCBs
- DU N-4 (Bishop Point): antimony, lead, mercury, zinc
- DU E-2 (Off Waiau Power Plant): total PCBs
- DU E-3 (Aiea Bay): lead, mercury, zinc

The FS also evaluated ongoing sources of chemicals released to Pearl Harbor, and identified, evaluated, and recommended remedial alternatives for remediation to protect human and ecological receptors potentially exposed to chemicals in the impacted sediments. Based on the screening of remedial action (RA) technologies, RA alternatives, and the evaluation and comparative analysis of retained alternatives, the FS recommended a combination of focused dredging, ENR, AC amendment treatment, and MNR as the selected remedy for the site.

- **Basis of Design Field Investigation (2017)**: The Navy conducted an additional field investigation as part of the BOD preparation. During the BOD field investigation, additional data and information was collected to complete the design of the selected remedial alternatives. The BOD field investigation provided the additional sediment data to refine the selected remedy implementation area (Figure 1-5) and provided more accurate estimates for the remediation costs (Table 1-1) presented in this ROD. Fish tissue samples were also collected during the BOD field investigation to provide additional baseline fish tissue data for long-term monitoring.

2.2.3 Enforcement Activities

There have been no CERCLA enforcement activities at the Pearl Harbor Sediment site.

2.3 COMMUNITY PARTICIPATION

Public participation in the decision process for environmental activities at the Pearl Harbor Sediment site has continually been encouraged throughout the environmental restoration and site closure processes. In an effort to involve the public in the decision-making process, a Restoration Advisory Board (RAB) was established. The RAB is composed of DOH, Navy, and community representatives. The Navy has held RAB meetings (typically on a semi-annual basis) and other public meetings since 2003, as well as issued fact sheets that summarize the site investigation and cleanup activities. In addition, the Navy established a point-of-contact for the public at Naval Facilities Engineering Command (NAVFAC) Pacific.

A PP was prepared to formally present the preferred remedy to the public and to solicit public comments. A public meeting for the PP was held on February 10, 2016 at Aiea Elementary School, Oahu, Hawaii. A notice of the public meeting and availability of the PP was published in the *Honolulu Star-Advertiser* on January 24, 2016, 2 weeks prior to the public meeting. The public comment period for the PP was initially held between February 1, 2016 and March 1, 2016. The comment period was later extended to April 1, 2016, and the notice to extend the public comment period for the PP was published in the *Honolulu Star-Advertiser* on February 28, 2016. Questions and concerns received during the meeting were addressed at the meeting and documented in the meeting transcript. Responses to written comments received during the comment period are presented in the Responsiveness Summary (Attachment B).

The PP and other project documents, including WPs, technical reports, the RI report, RI Addendum report, FS, and other materials relating to the Pearl Harbor Sediment site, can be found in the information repositories at the following addresses:

Aiea Public Library
99-143 Moanalua Road
Aiea, Hawaii 96701
808-483-7333

Ewa Beach Public Library
91-950 North Road
Ewa Beach, Hawaii 96706
808-689-1204

Pearl City Public Library
1138 Waimano Home Road
Pearl City, Hawaii 96782
808-453-6566

Hamilton Library at the University of Hawaii at Manoa
Hawaiian and Pacific Collection
2550 McCarthy Mall
Honolulu, Hawaii 96822
808-956-8264

Additional project information is located in the AR file at NAVFAC Pacific in JBPHH. The address for the AR file is provided below:

Naval Facilities Engineering Command, Pacific
258 Makalapa Drive, Suite 100
Attn: NAVFAC PAC EV3
JBPHH Hawaii 96860-3134

2.4 Scope and Role of the Response Action

The Pearl Harbor Sediment site is part of the PHNC NPL site. A Federal Facility Agreement (FFA) for the PHNC was finalized in 1994 (EPA, State of Hawaii, and DON 1994). The FFA documents how the Navy intends to meet and implement CERCLA in partnership with EPA Region 9 and the DOH. To ensure that human health and the environment remain protected from elevated chemical concentrations in sediment (Figure 1-3), the selected remedy includes a combination of focused dredging, ENR, AC amendment treatment, and MNR. The selected remedy and refined remedy implementation area are presented on Figure 1-5.

Remedial alternatives specific to each DU were developed and evaluated based on the unique physical, chemical, and biological characteristics of each of the six DUs. The remedial actions selected as components of the remedy for each DU take advantage of ongoing natural recovery through implementation of ENR, in-situ treatment with AC amendment, and MNR. It is expected that remediation will be performed concurrently or sequentially for all DUs, and, therefore, will include a mix of remedial construction for dredging, capping, and ENR, as well as monitoring for MNR. Coordinating these activities with site investigations and maintenance dredging activities at potential upland sources will be crucial to optimizing the efficiency of remedial efforts for Pearl Harbor.

Through the FFA, the Navy, EPA, and DOH have agreed to:

- Ensure that environmental impacts associated with past and present activities conducted are thoroughly investigated and that appropriate RAs are taken, as necessary, to protect public health, welfare, and the environment.
- Establish a procedural framework and schedule for developing, implementing, and monitoring appropriate RAs in accordance with CERCLA, SARA, NCP, Superfund guidance and policy, RCRA guidance and policy, and applicable State of Hawaii law.
- Facilitate cooperation, exchange of information, and participation between the Navy, EPA, and DOH.
- Ensure adequate assessment of potential injury to natural resources necessary to ensure the implementation of RAs appropriate for achieving suitable clean-up levels.

The remedy for the Pearl Harbor Sediment site was chosen in accordance with CERCLA, as amended by the SARA, and to the extent practicable, the NCP. Information supporting the decisions leading to the selected remedy is presented in the FS report (DON 2015).

2.5 SITE CHARACTERISTICS

This section describes the site characteristics at the Pearl Harbor Sediment site. Site characteristics include geology and soils, hydrology, sedimentation, and ecology.

2.5.1 Site Overview

2.5.1.1 PHYSICAL SETTING

Pearl Harbor is a delta-shaped natural estuary located on the south-central coast of the island of Oahu, Hawaii (Figure 1-1). The harbor's 36 miles of shoreline encompass approximately 5,000 acres of surface water within four major lochs (West, Middle, East, and Southeast) and a dredged navigation channel that opens to the Pacific Ocean on the south. It is situated at the south end of the central Oahu plain, which separates the island's two mountain ranges: Waianae on the west and Koolau on the east. Pearl Harbor is a natural trap, or sink, for sediments and chemicals present in approximately 110 square miles of watershed, or 20 percent of Oahu's land surface (Figure 2-1).

2.5.1.2 GEOLOGY

The island of Oahu consists of four major geomorphic provinces: Koolau Range, Waianae Range, Schofield Plateau, and Coastal Plain. The island was initially formed by two massive shield volcanoes, the Waianae and Koolau Volcanoes, rising from the floor of the Pacific Ocean. The eroded remnants of these shield volcanoes, the Koolau and Waianae Ranges, compose the island and are exposed as long, narrow, nearly parallel mountain ridges, which are separated by the Schofield Plateau (Figure 2-2). The Waianae and Koolau Volcanics are primarily tholeiitic and alkalic basalts, with minor amounts of more acidic rocks (e.g., rhyodacite). Banking of the younger Koolau flows against the older Waianae Range, and erosion of the two mountain ranges, formed the Schofield

Plateau in the central portion of Oahu. The Coastal Plain overlies the Koolau Volcanics at the north and south ends of the Schofield Plateau (Stearns 1985).

JBPHH is located on the coastal plain south of the Schofield Plateau (Figure 2-2). The JBPHH area is underlain by interbedded marine and terrestrial sediments that were deposited over the shield lavas during periods of sea-level transgression and regression (Stearns and Chamberlain 1967). The Pearl Harbor basin is a drowned river system, with several tributaries that form the three main lochs (West Loch, Middle Loch, and East Loch) that join to form a single channel entrance (Figure 2-2). Harbor bathymetry is characterized by shallow areas at the head of each loch, grading to deeper waters toward the center of the loch and in the main navigation channels. This change in depth is gentle in upper West Loch, but more abrupt in Middle and East Lochs, where extensive dredging has been conducted to maintain navigation depths necessary for the operation of naval vessels.

The geology of the Pearl Harbor area is the result of processes including sea level fluctuations, stream erosion, alluvial deposits, and volcanism. A cluster of overlapping volcanic tuff cones (Aliamanu, Salt Lake, and Makalapa Craters) composing the Honolulu Volcanics occurs east of Pearl Harbor. Volcanic tuff deposits dominate the area immediately east of the harbor. The Ewa Plain on the west side of the harbor is underlain by an extensive coralline limestone reef formation. Koolau basalts underlie most of the area north of the harbor. Caprock sediments overlie the Koolau basalts in some areas near the shoreline north of the harbor. A geologic map of the area around Pearl Harbor is presented on Figure 2-2.

Approximately 90 percent of the Pearl Harbor seafloor is classified as unconsolidated sediment, primarily terrigenous mud (silt and clay), and calcareous sand. The proportion of terrigenous mud relative to coarse, calcareous sand decreases in a seaward direction from inner Pearl Harbor toward the entrance channel. The unconsolidated sediment layer in the inner portions of the harbor is believed to be more than several meters thick. A submerged limestone/fossilized reef platform covered by a relatively thin layer of mud and sand surrounds much of the shoreline. At its outer edges, the limestone platform ends in a natural or dredged wall, or slopes more gradually to the Pearl Harbor seafloor.

2.5.1.3 HYDROLOGY

Surface Water. The Pearl Harbor watershed is characterized by a very steep precipitation gradient from the harbor to the crest of the Koolau range. Pearl Harbor is relatively dry, with a mean annual rainfall of between 50 and 76 centimeters (cm) (20 and 30 inches) compared to the crest of the Koolau range, where the mean annual rainfall may exceed 699 cm (275 inches). Rainfall is seasonal, varying from 7.6 cm (3 inches) during the winter (December–February) to 2.54 cm (1 inch) per month during the summer (June–July) (NAVFAC Pacific 2011).

The 110 square miles of overall watershed for Pearl Harbor are subdivided into nine distinct sub-watersheds, as shown on Figure 2-1. These subwatersheds contain the headwaters of nine streams that drain into Pearl Harbor (Figure 1-1): seven are perennial (Waikele, Kapakahi, Waiawa, Waimano, Waimalu, Kalauao, and Halawa), and two are intermittent (Honouliuli and Aiea). Waimano, Waimalu, Kalauao, Aiea, and Halawa Streams drain steep, relatively narrow valleys of the Koolau Range and thus transport substantial coarse sediment loads during storm events (WET 1991; Oki and Brasher 2003). Honouliuli and Waikele Streams drain the Schofield Plateau and typically transport large amounts of fine-grained sediment. The Waikele watershed is the largest, constituting approximately 40 percent of the overall Pearl Harbor watershed and discharging the heaviest sediment load of any Pearl Harbor Basin stream (Grovhoug 1992). All streams drain forested and agricultural lands and pass through highly urban areas before entering Pearl Harbor. The volume of fresh water entering Pearl Harbor has been estimated at 50 million gallons per day (mgd) during dry periods and greater than 100 mgd during rainy periods (Cox and Gordon, Jr. 1970; B-K Dynamics, Inc. 1972).

As reported in Grovhoug (1992), the mean depth of Pearl Harbor is 30 feet, with the deepest area located off Waipio Peninsula in the main channel at a depth of 92 feet. Tidal flow and circulation in Pearl Harbor are weak and variable, with a mean tidal current velocity of 0.3 knot and a maximum ebb flow of 0.6 knot in the entrance channel. The mean annual tidal range for Pearl Harbor is approximately 1.6 feet. Surface water circulation is driven primarily by northeasterly trade winds. Maximum residence time for bottom waters in Middle Loch is approximately 6 days, and in major channel areas and throughout East Loch, surface water residence times average 1–3 days. Vessel traffic has been identified as a major harbor-water mixing mechanism.

Groundwater. Groundwater movement in the Pearl Harbor area is controlled by local and regional hydrologic conditions that influence the supply and distribution of water in the sedimentary deposits and volcanic rocks (basalts) that underlie the harbor area (Youngberg 1973). Unconfined near-surface caprock groundwater occupies sediments that overlie and confine groundwater at lower levels within the basaltic bedrock that underlies the Pearl Harbor area. The caprock groundwater occurs in permeable sediments (sands and gravels) that overlie impermeable sediments (clays) that confine the deeper groundwater within the underlying fractured basalts. The caprock groundwater is recharged by water that infiltrates the near-surface sediments and percolates downward to the saturated zone below the water table. Both the near-surface caprock groundwater and the deeper confined groundwater flow toward the ocean, and are recharged by infiltration from rainfall, streams, and irrigation. In the northern Pearl Harbor area, groundwater discharge supports perennial stream flows and springs, while farther to the south, groundwater within the confined Koolau basalt aquifer exists under artesian conditions and discharges to Pearl Harbor or the Pacific Ocean (NEESA 1983).

Groundwater flow toward the harbor could act as a transport pathway for chemicals present in upland soils to reach Pearl Harbor. Chemicals present in upland soils could enter the groundwater except in areas overlain by sedimentary caprock and shoreline constructed of pier bulkhead. Once in the groundwater, chemicals may be transported to streams that discharge to the harbor or to the harbor directly.

2.5.1.4 SEDIMENTATION

Sedimentation is a major natural process defining the physical characteristics of Pearl Harbor. Freshwater streams in the Pearl Harbor watershed transport naturally occurring terrigenous sediment to the depositional environment of Pearl Harbor, which acts as a natural trap, or sink, for the sediment. These terrigenous sediments are the product of physical and chemical weathering of rock and soil in the Pearl Harbor watershed. Once the streams discharge sediments to the harbor, the distribution of sediment is influenced by hydrographical (i.e., water depths) conditions, sediment particles (i.e., grain size), and harbor currents. Larger sediment particles discharged to the harbor by streams are deposited rapidly near stream mouths, while smaller particles remain in suspension and are transported greater distances from a stream mouth before settling to the bottom of the harbor.

Hydrodynamic and sediment transport modeling of Pearl Harbor was conducted as part of the RI Addendum (DON 2013, Appendix C.2) to simulate hydrodynamics of the harbor and sediment transport. The evaluation concluded that harbor-wide hydrodynamics are driven by tides and freshwater discharged from five major streams that flow from the surrounding watersheds into the harbor, and that virtually the entire sediment load discharged to the harbor, approximately 578 tons/day, is attributable to the stream flows. The study results showed that the only potentially significant erosion mechanisms are resuspension by propeller wash in the main channels (rate of approximately 52 tons/day) and hurricane events (75,600 tons of resuspension per event). Natural hydrodynamic and transport processes in the harbor drive deposition of sediments entering the harbor from the major streams. An additional propeller wash study conducted by Wang et al. (2016) confirmed that propeller wash is a potentially significant erosion mechanism. The evaluation results confirm that all of Pearl Harbor is a deposition zone for sediments discharged from the streams, with deposition of the coarser sediments occurring at the stream mouths and finer sediments settling farther out in the four lochs and the navigation channel. The sediment transport modeling results indicate that recontamination of remediated areas within the harbor by sediment transport is unlikely because new sediments discharged from the major streams are relatively clean, and the low-energy conditions that dominate Pearl Harbor prevent erosion and transport of sediments to other locations within the harbor.

2.5.1.5 ECOLOGICAL HABITATS AND BIOLOGICAL COMMUNITIES

As a natural wetland, marsh, and swamp environment, Pearl Harbor has historically existed as a natural sedimentation basin (Grovhoug 1992). In addition to acting as a natural trap for chemicals entering Pearl Harbor, sediments are the natural habitat for many types of marine life, such as crabs and fish that live on the bottom of the harbor, and are part of the food web for many waterbird species and humans. The harbor area is generally characterized by high biological complexity and productivity, and the estuary is an important nursery area for many marine species.

The waters of Pearl Harbor contain two primary ecological zones based on substrate type: a soft bottom zone composed of unconsolidated sediment, and a hard substrate zone composed of fossilized coral reef material or anthropogenic items such as steel sheet piles, concrete piers, wooden piles, and sunken items (NAVFAC Pacific 2011, Appendix B2). A Smith et al. (2006) survey of the marine community in Pearl Harbor and the entrance channel reported that the standing population of fishes at some study sites had increased from previous surveys (Evans III 1974; Smith 2000, 2002). Stony corals and other key invertebrates that were absent or undetected during the extensive surveys in 1974 were returning, indicating improving environmental conditions. Individuals of a number of ecologically, recreationally, and commercially important fish species were significantly more common and significantly larger within Pearl Harbor than at other locations in the main Hawaiian Islands, attributable to the lack of civilian fishing pressure as a result of Navy control of the harbor over the last century. The study reported that sunken derelict items, hull fragments, and piers provide important habitat for fish, corals, and green sea turtles both in Pearl Harbor and in the entrance channel, and that these items should not be removed unless they create a navigational hazard. The alien gorilla seaweed *Gracilaria salicornia* threatened some areas, significantly reducing habitat complexity and leading to a decline in the standing population of fishes. The only protected marine species sighted within Pearl Harbor during the 2006 study was the threatened green sea turtle (*Chelonia mydas*), which is likely to enter and transit through Pearl Harbor occasionally but not reside there beyond the entrance channel. Similarly, no endangered Hawaiian monk seals (*Monachus schauinslandi*) are believed to reside within Pearl Harbor, the entrance channel, or the adjacent areas.

The Pearl Harbor shoreline includes several wetlands, primarily at West Loch, Middle Loch, and East Loch. These areas include the Pearl Harbor National Wildlife Refuge (PHNWR) established in 1976 and managed under a cooperative agreement among the Navy and federal and state resource agencies. The PHNWR includes two units within the former PHNC: the 24.5-acre Waiawa Unit at the northeastern shore of Middle Loch, and the 36.6-acre Honouliuli Unit on the western shore of West Loch (Figure 1-2). Both units provide habitat for several bird species, including four endangered, endemic waterbirds. The Hawaiian black-necked stilt (*Himantopus mexicanus knudseni*) and the Hawaiian coot (*Fulica alai*) are the two most abundant endangered waterbirds in the wildlife refuge units; the Hawaiian common moorhen (*Gallinula chloropus sandvicensis*) and Hawaiian duck (*Anas wyvilliana*) also inhabit the units (NAVFAC Pacific 2011).

2.5.2 Sampling Strategy

The RI, RI Addendum, FS, and BOD investigations included the following activities to provide the data needed to define the extent of sediment contamination that requires remediation, establish RAOs, assess recontamination and natural recovery potential and the need for source control, and evaluate alternatives for remedial action:

- Sediment, biota tissue, porewater, and surface water sampling and analysis
- Sediment toxicity analysis
- Investigation of under-pier sediments
- Investigation of sediments discharged from the tributary streams and storm drain outfalls
- Sediment transport studies and propeller wash modeling
- Geotechnical testing
- Survey of harbor bathymetry and morphology

2.5.3 Sediment Chemistry Data Evaluation

COCs concentrations reported for Pearl Harbor sediment samples are expressed and evaluated as point concentrations and as surface area–weighted average concentration (SWACs):

- **Point concentrations** are chemical concentrations representing sediment at a particular sampling location, and are typically applied to characterize small exposure areas (e.g., to evaluate exposure point concentrations [EPCs] for benthic organisms with small home ranges).
- **SWACs** are similar to simple arithmetic averages of point concentrations over a defined area, except that each individual concentration value is weighted in proportion to the area of sediment it represents. SWACs are widely used in sediment risk management to determine whether the RAOs have been achieved.

Each of the six DUs identified for active remediation was divided into sub-areas to calculate a SWAC for each DU-specific COC. The sub-areas were generated using Thiessen polygons based on combined surface sediment data obtained during the 2009 RI Addendum and 2012 FS investigations (DON 2009, 2015). Thiessen polygons are constructed by drawing straight lines at the midpoint between each data point. These lines are then bisected with perpendicular lines, which meet to form polygons corresponding to the area represented by each sample.

The following equation was used to calculate the SWAC for each COC:

$$\text{SWAC} = \frac{\sum A_i C_i}{\sum A_i}$$

Where:

A_i = surface area of the sub-area (Thiessen polygon) associated with sample *i*

C_i = COC concentration reported for sample *i*

Example SWAC Calculation: The following example illustrates application of the SWAC equation for sub-areas A, B, C, and D, where sub-area A has a concentration of 3 milligrams per kilogram (mg/kg) and a surface area of 10 acres, sub-area B has a concentration of 5 mg/kg and an area of 2 acres, sub-area C has a concentration of 50 mg/kg and an area of 15 acres, and sub-area D has a concentration of 15 mg/kg and an area of 12 acres:

$$\mathrm{SWAC} = 24.87 mg/kg = \frac{(3\,\mathrm{mg/kg} \times 10\,\mathrm{ac}) + (5\,\mathrm{mg/kg} \times 2\,\mathrm{ac}) + (50\,\mathrm{mg/kg} \times 15\,\mathrm{ac}) + (15\,\mathrm{mg/kg} \times 12\,\mathrm{ac})}{10\,\mathrm{ac} + 2\,\mathrm{ac} + 15\,\mathrm{ac} + 12\,\mathrm{ac}}$$

The simple arithmetic average concentration for this example is 18.25 mg/kg ([3 mg/kg + 5 mg/kg + 50 mg/kg + 15 mg/kg]/4). The area-weighted average takes into account the large (15-acre) area with a high COC concentration (50 mg/kg).

2.5.4 Conceptual Site Model

A harbor-wide CSM was initially developed and further refined in the RI and RI Addendum, respectively. Results of the RI Addendum and the FS investigations indicated that contaminated sediments that may require remedial action occur in six of the ten DUs designated for the site. The human health exposure pathway was identified as consumption of fish and crab, and direct contact with sediment and surface water. The principal exposure pathway for ecological receptors was identified as direct contact and ingestion of COCs in sediment or dissolved in sediment porewater by organisms living in or on the sediment surface, and exposure of higher-trophic-level organisms to COCs that bioaccumulate in the tissues of organisms lower on the food chain. The FS investigation results were used to refine the six DU-specific CSMs to identify the COCs, further define the extent of contaminated sediments that may require remedial action, confirm the conclusions of the ecological and human health risk assessments, and evaluate the potential for future recontamination and natural recovery. The COCs identified for each DU are subsets of the COPCs recommended in the RI Addendum report for further consideration. DU-specific COCs are presented in Table 2-1. The boundaries of the six remediation DUs were refined in the FS using a combined 2009 and 2012 surface sediment dataset to provide more consistency and representativeness of present-day surface sediment conditions. For each DU CSM, the following subsections describe the nature and extent of contamination, sediment transport CSM, source(s) of contamination, and natural recovery/recontamination potential. Figure 2-3 – Figure 2-5 show chemical fate and transport pathways, and the exposure pathway evaluations for human health and ecological receptors, respectively.

2.5.4.1 Biota Health

The data required for detailed DU-specific evaluation of trends in biota health are limited, but harbor-wide trends are reflective of source control efforts and provide information about general baseline conditions through time. A number of biological surveys have been completed in Pearl Harbor during the past several decades (e.g., Evans III 1974; Grovhoug 1992; Smith, Deslarzes, and Brock 2006; Coles et al. 1997, 2009). Metrics commonly assessed are the number of species present and number of individuals. The reported results are as follows:

- Evans et al. (1974): 388 taxa; 23 algae, 278 invertebrates, and 87 fishes collected or observed in the harbor during the 1971–1973 period
- Grovhoug (1992): 130 taxa; 79 invertebrates and 51 fishes
- Brock (1994): 96 taxa in East Loch
- Brock (1995): 99 taxa in East Loch

- Coles et al. (1997): 434 taxa; 36 algae, 1 spermatophytes, 338 invertebrates, and 59 fish species and higher taxa
- Coles et al. (2009): 298 species or higher taxa, 95 of which were introduced or of unknown origin

The surveys have demonstrated an increasing abundance of stony corals and the number and size of fishes in Pearl Harbor (Coles et al. 2009; Smith, Deslarzes, and Brock 2006). These metrics suggest that the environmental conditions have significantly improved due to the source control measures that have been implemented since the early 1980s.

Temporal COC concentration trends for fish in Pearl Harbor were evaluated by comparing the 2009 RI Addendum fish tissue data to data reported for collocated fish tissue samples collected for the initial RI sampling event in 1996. Collocated fish tissue samples were collected at 11 of the previous (1996) fish tissue sampling locations. Comparison of data representing the collocated 2009 fish tissue samples to the 1996 fish tissue data suggests that concentrations of most of the metals, total PCBs, pesticides, and PCDDs/PCDFs in Pearl Harbor fish tissues have decreased significantly since 1996.

Table 2-1: Summary of DU-Specific Sediment COC Concentrations

	Chemical Nature and Extent					
DU	Total DU Area (acres)	COC (Unit)	PRG	Maximum Concentration at Any Depth	Maximum Surface Concentration	SWAC
SE-1 (Southeast Loch)	277	Copper (mg/kg)	214	4,090	1,980	230
		Lead (mg/kg)	119	1,830	1,190	121
		Mercury (mg/kg)	0.71	20.7	14.8	1.4
		Total PCBs (µg/kg)	170 [a]	82,000	82,000	458
N-2 (Oscar 1 and 2 Piers Shoreline)	26.7	Cadmium (mg/kg)	3.2	21.5	6.8	2.0
		Copper (mg/kg)	214	792	1,880	199
		Lead (mg/kg)	119	302	388	110
		Mercury (mg/kg)	0.71	4.6	6.1	1.2
		Zinc (mg/kg)	330	805	1,760	315
		Total PCBs (µg/kg)	170 [a]	1,000	1,400	343
N-3 (Off Ford Island Landfill and Camel Refurbishing Area)	5.84	Total PCBs (µg/kg)	170 [a]	1,700	1,700	213
N-4 (Bishop Point)	5.25	Antimony (mg/kg)	8.4	29.8	20.2	5.9
		Lead (mg/kg)	119	4,110	4,110	664
		Mercury (mg/kg)	0.71	0.79	3.2	0.33
		Zinc (mg/kg)	330	1,280	944	381
E-2 (Off Waiau Power Plant)	18	Total PCBs (µg/kg)	110 [b]	4,200	4,200	938
E-3 (Aiea Bay)	88.9	Lead (mg/kg)	119	140	149	53
		Mercury (mg/kg)	0.71	2.4	2.4	1.1
		Zinc (mg/kg)	330	626	626	295

Note: Values presented in the table represent data and information collected up to and including the FS results.
µg/kg microgram per kilogram
mg/kg milligram per kilogram
Source: FS (DON 2015).
[a] Water depth 2 meters (6.6 feet) or greater.
[b] Water depth less than 2 meters (6.6 feet).

2.5.4.2 CSM FOR DU SE-1 (SOUTHEAST LOCH)

DU SE-1 extends across the southern portion of Southeast Loch, where sediments have been impacted by contaminant sources associated with naval activities (e.g., ship maintenance and repair). Most of the shoreline in this DU is lined with piers and berthing wharves that support Navy activities (Figure 2-6). The total area of DU SE-1 is approximately 277 acres. Water depths in the DU average approximately 45–50 feet. Most of DU SE-1 is located within the maintenance dredging footprint; therefore, water depths in this DU are linked primarily to maintenance dredging depth requirements. The average maintenance dredging period for each specific area is 7–20+ years. Within the nearshore repair basins and the inner lochs of the Southeast Loch basin (Magazine Loch, Merry Loch, Quarry Loch), water depths are approximately 30–40 feet, corresponding to the maintenance dredging elevation requirement for these areas. Comparison between the dredging depth requirements and current bathymetry data shows that water depths in most areas within the Southeast Loch dredging footprint are slightly shallower than the depths specified for the maintenance dredging program. A summary of the nature and extent of contamination, sediment transport, and natural recovery and recontamination potential for DU SE-1 is presented in Table 2-2.

Table 2-2: DU SE-1 (Southeast Loch) Conceptual Site Model Summary

	Description
Nature and Extent of Contamination	COCs identified for sediments in DU SE-1 are copper, lead, mercury, and total PCBs (Table 2-1). Spatial distribution of COCs in surface sediment for the DU is presented in Figure 2-7. Subsurface sediment PRG exceedances for DU SE-1 potentially extend deeper than 8 feet bswi in some areas based on available subsurface sediment core data with an average of 4.1 feet. Estimated total volume of sediments with concentrations exceeding PRGs is 1.8 million yd^3. COC exceedances in sediment extend to areas under the several piers present within the DU. The 2012 FS data indicate that the depth of contamination under the piers extends to approximately 3 ft bswi, which is the extent of the sediment thickness present in most piers. Part of DU is recommended for evaluation of long-term fish monitoring for total PCBs based on fish tissue exceedances reported in the 2009 RI Addendum field investigation.
Sediment Transport	Sediment transport modeling, radioisotope data, and shear stress data indicate that DU SE-1 is a net depositional environment and that erosion due to natural processes is not likely to expose buried sediments. The net sediment deposition rates as measured from the 2009/2012 radioisotope data are 0.4–1.4 in/y (1.1–3.6 cm/y) for under piers and 1.1 in/y (2.7 cm/y) for overwater areas (DON 2013, Appendix C) (Figure 2-8). Wave and current measurements recorded in 2009 and 2012 indicate an overall low energy environment for DU SE-1, including the under-pier areas. The only potential erosion mechanisms identified for DU SE-1 are propeller wash and extreme events (e.g., hurricanes). Propeller wash studies (DON 2013, Appendix C) suggest that major resuspension is limited to localized scouring from maneuvering vessels operating at high power, and that resuspended sediments would likely settle at or near the same locations from which they were removed. For Pearl Harbor, it is unlikely that typical transiting vessels will cause a significant redistribution of impacted sediments in DU SE-1. Additionally, propeller wash from vessel activities has the potential to enhance vertical mixing of the surface sediment layer. Sediment transport study (DON 2013, Appendix C) results indicate that although approximately 75,600 tons of sediment may be resuspended due to a hurricane event, a large percentage of sediment would be redeposited back at the same or adjacent location. Additionally, resuspension from hurricane events is limited to nearshore shallow areas.
Natural Recovery Potential	A detailed assessment of the natural recovery potential for DU SE-1 is presented in the FS report (DON 2015, Appendix G) and summarized below. The potential for natural recovery of sediments in DU SE-1 is considered good, as evidenced by the net sediment deposition rates observed for this DU, which indicate ongoing natural recovery via physical isolation (i.e., contaminated sediment burial) dispersion, or by mixing with incoming clean sediments. In addition, localized resuspension from propeller wash may enhance natural recovery by vertical mixing, dispersion, and gradual dilution of contaminated surface sediments with incoming clean sediments. The estimated sedimentation rate for DU SE-1 is greater than 1 cm/y. Fish tissue data indicating that conditions improved between 2009 and 2012 provides additional supporting evidence for ongoing natural recovery.

Table 2-2: DU SE-1 (Southeast Loch) Conceptual Site Model Summary

	Description
Recontamination Potential	Potential sources for recontamination of DU SE-1 sediments include releases from docks and piers, ships, storm drain outfalls that may convey runoff from surrounding Navy IR sites (e.g., transformer sites), permitted industrial discharges from the Dry Docks, and exposure of subsurface sediment from future maintenance dredging activities. The highest total PCB concentration (80,000 µg/kg) reported for surface sediment in Pearl Harbor represents sediments located off a storm drain outfall near Dry Dock 3; this concentration may potentially be attributable to historical releases from the outfall. The NPDES permit for six outfalls from the four dry docks in Pearl Harbor Naval Shipyard allows for discharge of wastewater from caisson leakage, “BMP- [best-management-practice-] clean” rainfall, groundwater seepage, single-pass cooling, pump test tailwater, hydroblast tailwater, and hull rinsing. The outfall discharge must meet Hawaii water quality standards (HAR 11-54 [DOH 2014]), and site-specific BMPs must be implemented in order to comply with the standards. Under the NPDES permit, the discharge is regulated for copper, lead, and mercury, which are included in the list of COCs for DU SE-1. Sewage discharge has been eliminated as a potential source (DON 2013). The highest potential for recontamination in DU SE-1 is associated with exposure of contaminated subsurface sediments during maintenance dredging and discharge of contaminated sediments from the storm drain outfalls. The maintenance dredging activities have the potential to continue to re-expose subsurface contaminated sediments unless (a) remedial action includes partial dredging to create a clean buffer zone for future maintenance dredging activities, or (b) the maintenance dredging elevation is changed. Storm drain inlet studies conducted within the Shipyard and Makalapa have investigated soil and sediments within storm drain inlets near land sites that lie along the storm water conveyance system that discharges into the DU. The studies identified several sites with reported COC concentrations above the land-based project-specific screening criteria in sediments located within the storm drain inlets as well as in soils surrounding the sites. Additionally, not all IR sites present along the storm drain outfall conveyance system have been completely investigated; therefore, storm drain outfalls remain a potential source of recontamination. The Navy is currently initiating cleanup of contaminated sediment in the storm drain system within the Shipyard area after a SI recommended further action there (DON 2011). The Tier 2 sediment transport study reported the potential for erosion of contaminated sediment by propeller wash (DON 2013); however, results of a propeller wash study by SPAWAR (Wang et al. 2013) indicate that that major resuspension is limited to localized scouring from maneuvering vessels operating at high power, and that the majority of resuspended sediment would likely settle at or near the same locations from which they were removed. Therefore, it is unlikely that typical transiting vessels will cause a significant redistribution of impacted sediments. The potential for recontamination by contaminants released with surface water and stream flow is considered minimal, based on low COC concentrations reported for sediment samples collected off Halawa Stream. Improved BMPs and the transient nature of ships in the harbor indicate that releases from ships are intermittent and may not represent significant ongoing sources of sediment contamination in the harbor. The potential for recontamination from permitted industrial discharge is considered low to moderate, given that under the NPDES permit the discharge is regulated for copper and lead; however, 2007 inspection of the permitted discharge indicates that although BMPs were being effectively implemented, water quality testing results showed chronic non-compliance that may require additional monitoring. Additionally, compliance data from 2009 to 2012 show that the copper concentrations reported for at least one of the Dry Dock outfalls exceeded the compliance criteria during seven of twelve quarters, while zinc concentrations exceeding the compliance criteria were reported for two quarters (EPA 2013).

BMP best management practice
bswi below the sediment-water interface
cm/y centimeter per year
ft foot or feet
HAR Hawaii Administrative Rules
in/y inch per year
IR Installation Restoration
NPDES National Pollutant Discharge Elimination System
SI site inspection

2.5.4.3 CSM for DU N-2 (Oscar 1 and 2 Piers Shoreline)

DU N-2 is located in the navigation channel region of Pearl Harbor. The shoreline of the DU is composed of the southern portion of the Navy Shipyard with Oscar 2 Pier to the north, Dry Dock 4 in the middle, and the non-operational Oscar 1 Pier to the south (Figure 2-9). DU N-2 has a total area of approximately 26.7 acres. Water depths within the DU range from less than 10 feet along the shallow shelf along the coastline under and to the south of Oscar 1 Pier and to the north of Oscar 2 Pier. A 50–60 foot-deep channel extends out from Dry Dock 4 to the navigation channel. The entire DU lies inside the maintenance dredging footprint. A summary of the nature and extent of contamination, sediment transport, and natural recovery and recontamination potential for DU N-2 is presented in Table 2-3.

Table 2-3: DU N-2 (Oscar 1 and 2 Piers Shoreline) Conceptual Site Model Summary

	Description
Nature and Extent of Contamination	The COCs for DU N-2 are cadmium, copper, lead, mercury, zinc, and total PCBs (Table 2-1). Spatial distribution of COCs in surface sediment within the DU is presented in Figure 2-10. Available subsurface sediment data indicate subsurface exceedances down to the maximum sampled depth, i.e., 4 ft bswi; therefore, sediment exceedances may extend to depths below 4 feet bswi. The estimated volume of sediment with COC exceedances is approximately 170,000 yd^3. This volume is likely an overestimate given that the 4-foot thickness is inferred for the whole DU area, whereas the actual thickness of sediments with COC exceedances will likely decrease toward the boundaries of the DU. The extent of contaminated sediment for the DU also includes areas under the Oscar 1 and 2 Piers. Sediments under the Oscar 2 Pier are only about 1 foot thick, and COCs with exceedances are limited to copper and total PCBs. A thicker sediment layer is present under Oscar 1 Pier, where high concentrations of all COCs extend to 3 ft bswi. The DU N-2 area is also recommended for evaluation of long-term fish monitoring for total PCBs.
Sediment Transport	The harbor-wide sediment transport model indicates a net sedimentation and depositional environment for DU N-2 at a relatively sedimentation rate of 0.07 in/y (0.17 cm/y) (DON 2013). However, deposition rate values from radioisotope data collected in 2012 indicate that sedimentation rate is greater than 1 cm/y. Similar to DU SE-1, the only potentially significant erosion mechanisms are identified as propeller wash and extreme events (e.g., hurricanes). Similar to DU SE-1, propeller wash studies suggest that major resuspension is limited to localized scouring from maneuvering vessels operating at high power, and that resuspended sediment would likely settle at or near the same locations from which they were removed. It is unlikely that typical transiting vessels will cause a significant redistribution of impacted sediments in DU N-2. Additionally, propeller wash from vessel activities has the potential to enhance vertical mixing of the surface sediment layer.
Natural Recovery Potential	The potential for natural recovery due to burial in DU N-2 is considered good because of the net deposition environment with estimated sedimentation rate based on radioisotope data that is greater than 1 cm/y. Fish issue data indicating that conditions improved between 2009 and 2012 provides additional supporting evidence for ongoing natural recovery. Vertical sediment COC concentration profile data indicate improving conditions off Oscar 2 Pier. However, the COC concentration profile for sediments near an outfall south of Dry Dock 4 and Oscar 1 Pier indicates that concentrations are stable or increase toward the sediment surface, indicating potential continuing input of contaminants localized to the area immediately off of the outfall. Results of additional geochemical association analysis (DON 2015, Appendix C.3) indicate that sediments near the outfalls are enriched in metal COCs relative to their iron content, suggesting contributions from contaminants released into the storm drain system.
Recontamination Potential	Potential non-point sources identified for DU N-2 may release contaminants to surface water flowing into the harbor. Potential point sources include releases from ships, and surface runoff from the piers as well as from IR sites located upgradient from the storm drain outfalls discharging into the DU. In addition, permitted (NPDES) industrial discharge from Dry Dock 4 is also identified as a potential source. The NPDES permit allows for discharge of wastewater from Dry Dock 4 and similar to DU SE-1, the outfall discharge must meet Hawaii Water Quality Standards (HAR 11-54, DOH 2014), and site-specific BMPs must be implemented in order to comply with the standards. Under the NPDES permit, the discharge is regulated for copper, lead, mercury, and zinc (DU N-2 COCs are cadmium, copper, lead, mercury, zinc, and total PCBs). However, NPDES compliance data from the past 3 years show that effluent from the two outfalls at Dry Dock 4 consistently have had compliance issues due to elevated concentrations of primarily zinc and also copper (EPA 2013). Periodic maintenance dredging has a high potential to re-expose subsurface sediment contamination unless the dredging elevation requirements are revised or the remedy includes over-dredging to gain sufficient clearance to avoid disturbance by future dredging operations. Storm drain outfalls have been identified as sources that pose high potential for recontamination. The Navy is currently initiating a sediment cleanup (DON 2012) within the Shipyard storm drain system after a SI recommended further action there (DON 2011). The most significant potential for recontamination is likely associated with discharge of suspended sediments from outfalls near Dry Dock 4 and south of Oscar 1 Pier. The Tier 2 sediment transport study reported the potential for erosion of contaminated sediment by propeller wash (DON 2013). The results of a propeller wash study by SPAWAR (Wang et al. 2013) indicate that that major resuspension is limited to localized scouring from maneuvering vessels operating at high power, and that resuspended sediments would likely settle at or near the same locations from which they were removed. Therefore, it is unlikely that typical transiting vessels will cause a significant redistribution of impacted sediments. The potential for recontamination of DU N-2 by contaminants released with surface water runoff from commercial/industrial properties and urban streets is considered minimal. Improved BMPs and the transient nature of ships in the harbor indicate that releases from ships are intermittent and may not represent significant ongoing sources of sediment contamination in the harbor.

2.5.4.4 CSM FOR DU N-3 (OFF FORD ISLAND LANDFILL AND CAMEL REFURBISHING AREA)

DU N-3 is located in the navigation channel adjacent to the western shoreline of Ford Island. Land along the shoreline of the DU is occupied by Navy housing and the Ford Island Landfill along the central and the southern portion of the DU (Figure 2-11). DU N-3 covers a surface area of approximately 5.8 acres. The shoreline is characterized by hard substrate consisting of rubble, sand, and rip-rap. Refusal was frequently encountered in this area during sediment core sampling in 2009 and 2012, indicating that sediment layer within the DU is relatively thin. Most of the DU lies along a shallow shelf with water depths less than 10 feet. The DU is located entirely outside the maintenance dredging footprint. One primary storm drain outfall discharges into the DU from the storm water conveyance system in the southwestern portion of the DU. A summary of the nature and extent of contamination, sediment transport, and natural recovery and recontamination potential for DU N-3 is presented in Table 2-4.

Table 2-4: DU N-3 (Off Ford Island Landfill and Camel Refurbishing Area) Conceptual Site Model Summary

	Description
Nature and Extent of Contamination	Total PCBs is the only COC for DU N-3 with SWAC that is only slightly above the PRG of 170 µg/kg. Figure 2-12 presents the spatial distribution of contamination in surface sediment within the DU. No exceedances were reported for subsurface sediment samples collected in 2012, which were collected at locations outside the current DU boundary. Data reported for subsurface sediment samples collected in 2009 at locations in the southern portion of the DU indicate that PCB contamination is limited to the upper 1 foot of sediment. The volume of sediment with COC concentrations exceeding the PRGs is estimated at approximately 9,241 yd^3, based on the assumption that exceedances are limited to sediments above 1 foot bswi. The DU N-3 area is also recommended for evaluation of long-term fish monitoring for total PCBs.
Sediment Transport	The sediment transport evaluation results indicate that all areas within the navigation channel are depositional and that erosion is not likely to expose buried sediment, although the deposition rates are very low, e.g., only 0.05 in/y (0.12 cm/y), based on Tier 2 sediment modeling (DON 2013, Appendix C.2). The predominance of sand reported for the surface sediment samples suggests that the sediments were eroded from the nearby shoreline during high-energy surface water runoff events or due to winnowing form wind and/or wave activities. The entire DU is located outside the maintenance dredging footprint. The shallow water suggests that the DU is not used for navigation, and therefore will not be affected by plume resuspension from propeller wash or impacted by maintenance dredging activities.
Natural Recovery Potential	The natural recovery potential for DU N-3 is limited due to the low deposition rates and the absence of nearby sources of clean incoming sediments. However, deposition rates in this area are likely comparable to other areas that have no direct input of sediment from streams. Fish tissue data indicating that conditions improved between 2009 and 2012 provides additional supporting evidence for ongoing natural recovery. In addition, the DU is not subject to maintenance dredging (which could potentially disrupt or enhance ongoing natural recovery processes). The vertical sediment profile data indicate that contamination is limited to the upper 1 foot of sediments. Sediment trap samples collected near the outfall indicate detectable levels of total PCBs in settling sediments, suggesting continuing input of PCBs into the DU from the outfall or locally resuspended surface sediment.
Recontamination Potential	Non-point sources include contributions from industrial lands surrounding the harbor that discharge to the DU. Surface water flow directly into the harbor is also identified as a non-point source. Potential point sources include the adjacent Ford Island Landfill slope, the former Camel Refurbishing Area to the north, and other Ford Island IR sites along the storm water drainage system that discharges into the DU. Unlike DU SE-1 and DU N-2, DU N-3 lies entirely outside the maintenance dredging footprint; therefore, exposure of contaminated sediments during maintenance dredging is not included as a potential source for this area. Storm drain outfall sampling data indicate high total PCB concentrations in surface sediment off the storm drain outfall located south of the Ford Island Landfill. Suspended sediment data representing the same location indicate incoming sediments with detectable total PCB concentrations, suggesting that upgradient IR sites could potentially contribute to recontamination.

2.5.4.5 CSM FOR DU N-4 (BISHOP POINT)

DU N-4 is the southernmost DU along the navigation channel, closest to the Pearl Harbor Entrance Channel. The shoreline is characterized by piers for berthing ships and Navy facilities. The DU covers a surface area of approximately 5.25 acres (Figure 2-13). The entire DU is located along a shallow shelf with water depths less than 25 feet, and is reportedly inside the maintenance dredging area. The designed dredge elevation for the DU is 22 feet mean lower low water. The average dredging frequency is approximately every 14 years, with the last maintenance dredging event conducted in 2011. A limited amount of sediment is present in the area based on repeated refusals encountered during subsurface sediment core sampling efforts, indicating the presence of hard substrate at approximately 3 feet below the sediment-water interface. Two primary outfalls discharge into the DU: one located between the two finger piers extending out from the center of the DU, and the other outfall located off the small peninsula bounding the southern portion of the DU. A summary of the nature and extent of contamination, sediment transport, and natural recovery and recontamination potential for DU N-4 is presented in Table 2-5.

Table 2-5: DU N-4 (Bishop Point) Conceptual Site Model Summary

	Description
Nature and Extent of Contamination	The COCs for DU N-4 are antimony, lead, mercury, and zinc (Table 2-1). The extent of surface sediment exceedances is primarily confined to the areas off Alpha 4 and Alpha 1 Piers in the southern portion of the DU. As shown, the SWACs calculated for both lead and zinc exceed the sediment screening criteria. Figure 2-14 presents the spatial distribution of COPCs in surface sediment within the DU. Subsurface sediment data indicate COC exceedances up to a depth of 3 feet bswi. Assuming an average thickness of 3 feet throughout the DU, the estimated volume of sediment with COC exceedances is approximately 25,410 yd^3. Contaminated sediments are also present under the piers, extending down to at least the maximum sampling depth of 3 feet bswi below Alpha 4 Pier, and 2 feet below Alpha 1 Pier. The DU N-4 area is also recommended for evaluation of long-term fish monitoring for total PCBs.
Sediment Transport	The sediment transport evaluation results indicate net depositional environment. Tier 2 sediment modeling (DON 2013, Appendix C.2) indicate that deposition rate is low at 0.04 in/y (0.13 cm/y); however, additional radioisotope data collected in 2012 indicate that deposition rate in the area is greater than 2.2 cm/year. DU N-4 is located entirely inside the maintenance dredging footprint, because the piers within the DU are active and routinely used for berthing of shallow-draft vessels. Limited ship traffic, the relatively shallow draft, and low velocities of the vessels operating in the area indicate that the potential for resuspension from propeller wash is limited. Additionally, propeller wash from vessel activities has the potential to enhance vertical mixing of the surface sediment layer.
Natural Recovery Potential	The potential for recovery due to burial is considered good based on the estimated sedimentation rate from radioisotope data (greater than 1 cm/y). The 2009 Tier 2 sediment transport modeling and 2012 radioisotope data confirm that sediments deposited in the DU are accumulating over time, suggesting that natural recovery is occurring due to burial. High-resolution core data collected off Alpha 1 Pier and Alpha 4 Pier indicate a steady increase of COC concentrations toward the surface but a rapid decrease in the upper 4 inches of the sediment column, supporting the conclusion that clean sediments are burying the contaminated sediments. Fish tissue data indicating that conditions improved between 2009 and 2012 provides additional supporting evidence for ongoing natural recovery.

	Description
Recontamination Potential	Because DU N-4 is located inside the maintenance dredging footprint, exposure of buried contamination during maintenance dredging is also identified as potential source. Potential point sources include releases from ships, surface runoff from the piers, runoff from other IR sites located on Bishop Point, and releases from the two storm water drainage systems that discharge into the DU. Metals concentrations reported for sediment samples collected near the storm drain outfalls suggest that the outfalls may act as continuing sources of contamination. A suspended sediment sample collected from a central outfall location showed high levels of metals; however, it is suspected that these sediments are resuspended sediments from the harbor bottom, based on characteristics and texture of the sediment trap sediments, which are similar to those of the surrounding bottom sediments (DON 2015). The potential for recontamination is considered moderate to high due to the potential exposure of contaminated sediments during maintenance dredging, continuing discharge from storm drain outfalls, runoff from IR sites, and erosion of contaminated sediments in the under-pier areas. Contaminated subsurface sediments may be exposed during future maintenance dredging activities. The elevated metals concentrations reported for sediment samples collected near the outfalls suggest that the potential for recontamination due to discharge from the outfalls is relatively high. Sediment trap data indicated high levels of COCs within the incoming suspended sediment; however, further observation revealed that these data likely represent resuspended sediments from the surrounding sediment bottom (DON 2015). Elevated zinc concentrations were reported for sediments near one of the outfalls, indicating that some of the sediment contamination may be attributable to roof runoff discharged to the storm drain system (zinc is a common contaminant in roof runoff). The relatively steep slopes observed under the piers in this DU (37–43 degrees) indicate that sediments under the piers may be unstable, and could potentially recontaminate the adjacent harbor sediments. The Tier 2 sediment transport study reported the potential for erosion of contaminated sediment by propeller wash (DON 2013, Appendix C.2). However, a study by SPAWAR (Wang et al. 2013) indicated that the potential for recontamination from sediment eroded by propeller wash is low. The potential for recontamination due to surface water runoff is also considered minimal. Improved BMPs and the transient nature of ships in the harbor indicate that releases from ships are intermittent and may not represent significant ongoing sources of sediment contamination in the harbor.

2.5.4.6 CSM FOR DU E-2 (OFF WAIAU POWER PLANT)

DU E-2 is located along the northwest shoreline of East Loch, off the Waiau Power Plant, which is owned and operated by the Hawaiian Electric Company (HECO) (Figure 2-15). The total extent of the sediment contamination is approximately 18 acres. The DU is composed of two sub-areas: a deep-water (primary) sub-area east of the sheet piling groin structure extending out from the power plant, and a smaller (secondary) sub-area located near the west end of the power plant property, off an outfall draining a pond from the power plant. The average water depth in DU E-2 is approximately 4 feet. The power plant discharge outfall is located east of the groin structure, in the primary sub-area of the DU. A residential area lies adjacent to the eastern portion of the DU. Two City and County of Honolulu (CCH) storm drain outfalls are located near but outside the DU boundaries: one to the west of the smaller sub-area of the DU near the Waimano Stream mouth, and the other draining the residential area along the eastern shoreline of the primary sub-area and discharging east of the DU boundary. Both sub-areas of DU E-2 are located outside the maintenance dredging footprint, and vessel traffic is limited. None of the available evidence suggests that previous or current Navy activities could have contributed to the PCB contamination reported for this DU. A summary of the nature and extent of contamination, sediment transport, and natural recovery and recontamination potential for DU E-2 is presented in Table 2-6.

Table 2-6: DU E-2 (Off Waiau Power Plant) Conceptual Site Model Summary

	Description
Nature and Extent of Contamination	Total PCBs is the only COC identified for DU E-2. High concentrations of total PCBs occur in sediments within the sub-area east of the groin, with a maximum reported surface sediment concentration of 4,200 µg/kg. Additionally, a small area of total PCB exceedances is located off the outlet of what appears to be a settling pond within the power plant compound. As shown in Table 2-1, the SWAC for total PCBs (938 µg/kg) exceeds the shallow-water PRG developed for protection of waterbirds (110 µg/kg). Figure 2-16 presents the spatial distribution of COCs in surface sediment within the DU. Data reported for subsurface sediment samples collected from the area east of the groin in 2009 indicate exceedances within the upper 2 feet of the sediment column. The estimated volume of sediments with total PCB concentrations exceeding the screening criterion is 58,100 yd^3. The DU E-2 area is also recommended for evaluation of long-term fish monitoring for total PCBs.
Sediment Transport	The sediment transport evaluation results indicate that all areas within East Loch are depositional and that erosion is not likely to expose buried sediment. The two sub-areas of DU E-2 lie outside the maintenance dredging footprint, with limited ship traffic; therefore, sediments are not likely to be resuspended by propeller wash. However, periodic discharge of a large flux of water from the power plant outfall has the potential to resuspend sediments. Radioisotope data reported for a 2012 sediment core sample collected east of the groin indicate a sedimentation rate of 0.33 in/y (0.86 cm/y). The radioisotope results indicate that the overlying sediments may have been removed in the past (i.e., by dredging) based on the absence of detectable Cs-137, despite evidence of sedimentation indicated by the Pb-210 profile.
Natural Recovery Potential	The sediment transport modeling and radioisotope data indicate a net depositional environment for DU E-2, suggesting that natural recovery via physical isolation (e.g., burial by clean sediment) could contribute to remediation of this DU. Although the sediment data show no distinct temporal concentration trends that would provide additional evidence of ongoing natural recovery, the fish tissue data indicate that conditions improved between 2009 and 2012, suggesting that natural recovery is occurring. The DU is not subject to maintenance dredging; therefore, natural recovery will not be impacted by future maintenance dredging.
Recontamination Potential	Potential contaminant sources that have likely contributed to the sediment contamination in DU E-2 include point sources as described below and non-point sources associated with surrounding commercial/industrial properties. Two storm drains (Figure 2-16) represent potential point sources; however, data collected off the CCH storm outfall to the east indicate very low total PCB concentrations, suggesting that this outfall is not a source of the sediment contamination. The data suggest that surface water runoff and/or the storm drain outfall associated with the Waiau Power Plant are the primary contaminant sources for DU E-2. The areal distribution of PCBs in DU E-2 sediments (Figure 2-16) shows that COC concentrations decrease with distance away from the shoreline, and therefore supports this conclusion. In addition, permitted (NPDES) industrial discharge from an outfall at the east end of the Waiau Power Plant is also identified as a potential source. The NPDES permit allows for discharge of wastewater from the Waiau Power Plant. The outfall discharge must meet Hawaii Water Quality Standards (HAR 11-54, DOH 2014), and site-specific BMPs must be implemented to comply with the standards. The NPDES permit regulates the discharge for contaminants including copper, lead, and zinc (the sole DU E-2 COC is total PCBs). No Navy sources with the potential to contaminate or recontaminate sediments have been identified for DU E-2 based on available data. Data reported for suspended sediment samples collected near the CCH storm drain outfall west of the DU indicate the presence of detectable PCB concentrations in the incoming sediments; however, the data indicate that the CCH outfall has not contributed significantly to the PCB contamination and is not a likely source of recontamination. The primary source of contamination and potential recontamination is runoff and discharge from Waiau Power Plant.

2.5.4.7 CSM FOR DU E-3 (AIEA BAY)

DU E-3 is located at the east end of East Loch and encompasses all of Aiea Bay (Figure 2-17). The banks of Aiea Stream, the primary water drainage feature discharging into the DU, are lined with concrete or soil, and the stream is ephemeral, with a tendency for flash flooding during periods of heavy rainfall. The refined DU boundary covers all of Aiea Bay, except the Rainbow Marina area, for a total surface area of 88.9 acres. The exclusion of Rainbow Marina is based on the results of the RI Addendum and the FS data, which indicate no exceedances in the Rainbow Marina area. The Aiea Bay shoreline consists primarily of vacant open spaces with overgrown vegetation. An asphalt-paved public bicycle path maintained by the CCH parallels the shoreline along inner Aiea Bay. Most of the shoreline area in DU E-3 is Navy property, with a small section designated as a public park along the northern shoreline of Aiea Bay. Navy property along the shoreline includes the land between Aiea Bay and the bicycle path, the Admiral’s Boathouse, and the Rainbow Marina. The nearshore inner portion of the DU is characterized by shallow-water tidal mudflats (water depths less than 5 feet); the outer portion of the DU is characterized by deeper water depths (up to 24 feet). A summary of the nature and extent of contamination, sediment transport, and natural recovery and recontamination potential for DU E-3 is presented in Table 2-7.

Table 2-7: DU E-3 (Aiea Bay) Conceptual Site Model Summary

	Description
Nature and Extent of Contamination	COCs for DU E-3 are lead, mercury, and zinc. The maximum lead concentrations are relatively low compared to the sediment PRG, whereas maximum mercury and zinc concentrations are approximately three and two times their PRGs, respectively. As shown in Table 2-1, mercury is the only COC with a SWAC exceeding its sediment PRG. Figure 2-18 presents the spatial distribution of COPCs in surface sediment within the DU. Data reported for subsurface sediment samples collected in 2009 indicate that COCs exceedances extending down to a depth of approximately 5 feet bswi within inner Aiea Bay and limited to the upper 3 feet of the sediment column near the center of the DU. The data indicates decreasing thickness of contaminated sediment with distance from the shoreline. Assuming an average vertical extent of 2.5 feet DU-wide, the estimated volume of sediment with COC exceedances is approximately 358,563 yd^3. The DU E-3 area is recommended for evaluation of long-term fish monitoring for total PCBs.
Sediment Transport	Sediment transport modeling and radioisotope data indicate that all areas within East Loch are depositional and that erosion is not likely to expose buried sediments. DU E-3 is located outside the maintenance dredging footprint, and navigation traffic is limited to small boats with shallow drafts; therefore, the potential for resuspension of sediments by propeller wash is considered minimal. Aiea Stream is the primary source of sediments deposited in DU E-3. Radioisotope data indicate a sedimentation rate of 0.16 in/y (0.41 cm/y); however, the estimated average sedimentation rate based on Tier 2 modeling is lower, at only 0.06 in/y (0.024 cm/y).
Natural Recovery Potential	A detailed analysis of the potential for natural recovery for DU E-3 is presented in the FS report (DON 2015, Appendix G) and summarized below. The sediment transport modeling and radioisotope data indicate a net depositional environment for DU E-3, suggesting that natural recovery via physical isolation (e.g., burial by clean sediment) could contribute to remediation of this DU. Fish tissue data indicating that conditions improved between 2009 and 2012 provides additional supporting evidence for ongoing natural recovery. The majority of the DU is located outside the maintenance dredging footprint, and ship traffic in the area is limited; therefore, the potential for disruption of ongoing natural recovery processes is considered limited.
Recontamination Potential	Recontamination of sediments within the DU by contaminants released from storm drain outfalls is unlikely based on the low concentrations detected in sediments around the outfalls and the suspended sediment samples collected with the sediment traps. The data indicate that the Navy outfall off Substation G does not represent an ongoing contaminant source; however, the Aiea Stream data indicate a trend of increasing zinc concentrations toward the surface, suggesting a potential continuing source of zinc contamination for DU E-3. Available fish tissue data show slight reductions in total PCB and metal concentrations (including zinc) in fish tissues between 1996 and 2009. Non-point sources for DU E-3 include surrounding commercial/industrial properties and urban streets potentially contributing contaminants to the DU via Aiea Stream or surface water flow. Potential point sources include the Former Aiea Military Reservation (a FUDS). Releases from boats transiting and docking at Rainbow Marina (Figure 2-17) are also recognized as potential point sources. The elevated zinc concentrations reported for stream mouth sediment samples indicate some potential for recontamination of harbor sediments by surface water and stream flow discharge from Aiea Stream. Discharge from the outfall off the FUDS site also poses moderate potential for recontamination based on the elevated COC concentrations reported for surface sediment samples collected near the outfall. However, evaluation of iron-normalized COPC concentrations indicates that incoming sediments from both Aiea Stream and storm drain outfalls within the DU fall within the range of clean harbor sediments and clean stream sediments, and therefore the concentrations are likely part of the background population (DON 2015). The recontamination potential associated with releases from boats at Rainbow Marina is considered low.

FUDS Formerly Used Defense Site

2.6 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

2.6.1 Land Uses

JBPHH occupies the majority of the land area immediately surrounding Pearl Harbor, and approximately 75 percent of the harbor shoreline lies within its boundaries. New joint base facilities are developed as needed and may involve in-water construction and project-specific dredging. This development currently supports the following major activities (military and civilian operations) at JBPHH:

- JBPHH covers all command areas previously known as NAVSTA Pearl Harbor, Naval Submarine Base (SUBASE), and Hickam AFB following the 2010 base consolidation. The command area previously known as NAVSTA controls the waters of Pearl Harbor as well as many noncontiguous and submerged lands in and around the harbor. The total land area consists of approximately 830 acres, and submerged land includes another 4,960 acres. The area previously known as SUBASE occupies 123.5 acres of land that provides berthing and shoreside facilities for submarines in port, along with submarine maintenance and training facilities. The command area previously known as Hickam AFB occupies 2,850 acres of land, sharing its runways with adjacent Honolulu International Airport (HIA). Hickam and the HIA constitute a single airport complex operated under a joint-use agreement. Hickam is home to the 15th Airlift Wing (formerly the 15th Air Base Wing).
- Naval Supply Systems Command Fleet Logistics Center Pearl Harbor provides supply and logistic support services to fleet units and naval shore activities. It is located in six noncontiguous areas occupying approximately 800 acres of land.
- Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility is located within the main joint base on approximately 159 acres of land, where it functions as a major ship repair and overhaul facility. The maintenance operation includes industrial shops, quality control testing laboratory, and engineering and administrative offices.
- NAVFAC Hawaii, previously known as the Navy Public Works Center, Pearl Harbor, maintains Navy family housing units and utilities systems. It also provides public works, transportation support, engineering services, and shore facilities planning support. The main NAVFAC Hawaii complex is located on 71 acres of land approximately 1 mile east of the main entrance to JBPHH.
- JBPHH West Loch Annex, Pearl Harbor covers an area of approximately 4,092 acres, including approximately 1,425 acres at Waipio Peninsula. The West Loch Branch of Naval Magazine Lualualei is located within the former PHNC, as defined in the PHNC FAA (EPA, State of Hawaii, and DON 1994), adjacent to West Loch of Pearl Harbor. The facility is a Department of Defense ordnance storage facility with magazines, operating buildings, community and personnel support facilities, and wharves for loading and offloading ordnance.
- Naval Sea Systems Command Detachment/Naval Inactive Ship Maintenance Facility is located on a 14-acre strip of land along the northwest shoreline of Middle Loch, and the water area in the upper portion of the loch where several “mothballed” ships are moored. Approximately 2 acres of the site have been developed for maintenance operations.

Other Activities On and Adjacent to Pearl Harbor. Construction of commercial and light industrial complexes has accompanied urban development and growth of the Pearl City and Leeward areas. The sum of these past and present activities has resulted in mixed land uses, including various light industrial, municipal, commercial, urban, and agricultural activities. These activities have the potential to contribute broad ranges of chemicals to the Pearl Harbor estuary and its sediments.

The Navy anticipates that the Pearl Harbor Sediment site will continue to be restricted for Navy use, with limited public access to certain shoreline areas. No changes in land use are anticipated in the foreseeable future for the areas adjacent to the Pearl Harbor Sediment site.

2.6.2 Pearl Harbor Maintenance Dredging

JBPHH routinely dredges locations throughout the harbor to maintain the water depths required for navigation and other harbor operations. The first modern-day dredging of Pearl Harbor by the U.S. government was completed in 1903, when sand in the entrance channel was dredged to enable the passage of ships into the harbor. However, large craft including battleships were still unable navigate past existing hard reef structures until the Navy dredged a deep channel through the harbor entrance to allow passage of deeper-draft, ocean-going vessels. In December 1911, the USS *California* was the first large vessel to pass through the dredged entrance channel and into Pearl Harbor.

With the rapid development of NAVSTA Pearl Harbor in the following decades leading up to and during World War II, extensive dredging, construction, and alteration of habitats occurred. Docks and operational facilities were developed at Southeast Loch and Ford Island, and new lochs were dredged to accommodate larger ships. The massive land clearing and dredging activities created a need for disposal areas, which resulted in drastic alteration of the historic shorelines of the harbor that continued in the decades following the war. Extensive filling occurred at wetland areas and fishponds throughout the harbor and at locations including Waipio Peninsula, Pearl City Peninsula, Ford Island, and Makalapa Crater. Magazine Island in the area previously known as SUBASE was connected to the mainland with dredged spoils during World War II (DON 2010; NAVFAC Pacific 2011).

Maintenance dredging is typically performed on a 4–5 year cycle. Periodic U.S. Army Corps of Engineers (USACE) bathymetric surveys of the harbor are used to assist in prioritizing and scheduling areas for upcoming dredging events. Grovhoug (1992) reported that between 1959 and 1990, Navy maintenance dredging removed approximately 9 million cubic yards (yd^3) of material from Pearl Harbor. Today, sediments removed during maintenance dredging are generally disposed of at one of two places. The South Oahu Ocean Dredged Material Disposal Site (SOODMDS), established by the USACE and EPA Region 9, is an offshore disposal site for "clean" dredged material located approximately 3 miles south of the entrance to Pearl Harbor. Dredged material that fails EPA-stipulated criteria for open-ocean disposal at the SOODMDS is disposed of at the Navy's upland Waipio Confined Disposal Facility (CDF), located in the southern portion of Waipio Peninsula. Navy Region Hawaii's *Pearl Harbor Maintenance Dredging Plan* for 2010 (revised 2011) lists 11 dredging sites throughout the harbor scheduled for award between 2009 and 2017, totaling 3.4 million yd^3 of dredge material from an area of approximately 2,000 acres (USACE 2011, Attachment 2).

2.6.3 Groundwater and Surface Water Uses

As described in *Classification of Shallow Caprock Groundwater at Navy Oahu Facilities, Oahu, Hawaii* (DON 2007b), groundwater beneath JBPHH, Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility is not currently used for potable purposes, and the groundwater is not suitable for use as a source of drinking water in the future. The primary use for surface water in the harbor is for navigational purposes. Limited recreational uses are permitted and highly regulated in certain parts of the harbor.

2.7 SUMMARY OF SITE RISKS

Table 2-8 and Table 2-9 summarize the human health risk assessment (HHRA) and baseline ecological risk assessment (BERA) results for each COC. Details of the HHRA and BERA are presented in the Pearl Harbor Sediment RI report (DON 2007a). The risk assessment results, applicable or relevant and appropriate requirement (ARAR) criteria, and background metal concentration ranges were used to develop RAOs and PRGs for the Pearl Harbor Sediment FS, as detailed in Section 5 of the FS report (DON 2015). The HHRA identified the key risk drivers for development of human health risk-based threshold concentrations (RBTCs), and the RBTCs were then used to develop PRGs. Development of the RBTCs and PRGs is presented in Section 5 of the FS report (DON 2015).

2.7.1 Human Health Risk Assessment

The HHRA identified the exposure pathways of potential concern for human health at the site as consumption of fish and crab, and direct contact with sediment and surface water (DON 2007a). The HHRA results indicated that the risks attributable to ingestion of fish and crab tissue are greater than those posed by exposure to sediment and surface water. In addition, the human health risk posed by consumption of fish was found to be greater than the risk posed by consumption of crab; therefore, if the fish consumption risk is reduced to an acceptable level, the crab consumption and direct contact risk will also be reduced to an acceptable level.

The risk posed by ingestion of fish based on the 2007 HHRA is presented below.

Cancer Risk. The HHRA (DON 2007a) results indicated that the cumulative reasonable maximum exposure (RME) cancer risk estimates for the ingestion of fish tissue exceeded the upper end of the EPA's acceptable risk range of 10^{-4} for the following scenarios:

- Adult residential (3×10^{-4})
- Adult subsistence (2×10^{-3})
- Child subsistence (6×10^{-4})

Arsenic, total PCBs, and dioxin TEQ were identified as the main cancer risk drivers; however, arsenic and dioxin TEQ were eliminated as COPCs because no screening criteria exceedances were reported for the sediment samples collected in 2009 for the RI Addendum (DON 2013). Therefore, total PCBs is the only chemical that drives cancer risk. RME cancer risks greater than 1×10^{-4} were calculated for the following human receptors for the adult subsistence scenario (2×10^{-4}) (Table 2-8).

Non-Cancer Hazard. The HHRA (DON 2007a, Appendix I) results also indicated that the cumulative non-cancer hazard index (HI) due to fish ingestion was greater than the target HQ of 1 for the following scenarios:

- Adult residential (18)
- Child residential (32)
- Adult subsistence (114)
- Child subsistence (199)
- Adult recreational (1.8)
- Child recreational (3.2)

The primary non-cancer hazard risk drivers identified in the HHRA were antimony, arsenic, chromium, copper, nickel, MCPP, total PCBs, and iron. The RI report (DON 2007a) recommended iron for no further consideration because iron is an essential nutrient and the concentrations are consistent with background conditions. MCPP was eliminated as a COPC in the RI Addendum WP because the RI screening criteria for MCPP were based on highly uncertain data and the risk attributable to MCPP was most likely overestimated (DON 2009, Section 10.4.2). Arsenic, chromium, and nickel were eliminated as COPCs based on the RI Addendum results (DON 2013) due to lack of screening criteria exceedances in the 2009 RI Addendum dataset. Therefore, antimony, copper, and total PCBs are the remaining drivers for non-cancer hazards. Non-cancer hazard quotients (HQs) greater than the target HQ of 1 were calculated for the following human receptors (Table 2-8):

- Adult resident (total PCBs: 1.8)
- Child resident (total PCBs: 3.2)
- Adult subsistence (antimony: 1.2; total PCBs: 12)
- Child subsistence (antimony: 2.1; copper: 1.6; total PCBs: 20)

No non-cancer HQs are above the target HQ of 1 for adult and child recreational scenario.

Table 2-8: Pearl Harbor Sediment COCs and Summary of Cumulative Human Health Risks

COC	Human Health Risk Driver?: Pathway	RME Excess Cancer Risk						Non-Cancer Hazard (HQs)					
		Residential		Recreational		Subsistence		Residential		Recreational		Subsistence	
		Adult	Child	Adult	Child	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Antimony	Yes: Fish Ingestion	[a]	[a]	[a]	[a]	[a]	[a]	0.2	0.3	0.02	0.03	***1.2***	***2.1***
Cadmium	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Copper	Yes: Fish Ingestion	[a]	[a]	[a]	[a]	[a]	[a]	0.1	0.3	0.01	0.03	0.9	***1.6***
Lead	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mercury	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total PCBs	Yes: Fish Ingestion	3×10^{-5}	1×10^{-5}	3×10^{-6}	1×10^{-6}	***2×10^{-4}***	7×10^{-5}	***1.8***	***3.2***	0.2	0.3	***12***	***20.1***

Note: ***Bold italic value*** indicates cancer risk is outside the EPA risk management range or non-cancer risk is greater than the target HQ of 1.
N/A not applicable because chemical is a COC based on ecological risk, not human health risk.
[a] Not calculated; no cancer slope factor data available (DON 2007a, Appendix I).

2.7.2 Ecological Risk Assessment

The BERA (DON 2007a, Appendix M) identified the principal exposure routes of concern for ecological receptors in Pearl Harbor as the following:

- Direct contact and ingestion of chemicals in or on sediment particles and dissolved in sediment porewater by organisms living in or on the sediment surface (e.g., benthic and epibenthic invertebrates)
- Exposure of higher-trophic-level organisms (e.g., fish and waterbirds) to chemicals that bioaccumulate in the tissues of organisms lower on the food chain

The BERA identified the following four groups of marine life as the AE to evaluate risk to ecological receptors:

- AE-1: Invertebrates living in sediment (macroinfauna) – represented primarily by burrowing shrimp (e.g., ghost shrimp and snapping shrimp)
- AE-2: Invertebrates living on sediment (epifauna) – represented by the blue-clawed stone crab
- AE-3: Bottomfish – represented by the bandtail goatfish and tilapia that live on or near the sediment
- AE-4: Waterbirds – represented by the Hawaiian stilt, Hawaiian coot, black-crowned night heron, wandering tattler, and sooty tern that consume food items living in, on, or in association with the sediment (i.e., macroinfauna, crabs, and bottomfish, respectively)

Table 2-9 presents a summary of ecological risks and HQ values calculated based on the lowest-observed-adverse-effect level for each COC. The BERA identified potentially unacceptable risk to from the following chemicals for ecological receptors:

- AE-1: macroinfauna (burrowing shrimp) – copper, lead, and zinc
- AE-2: epifauna (blue-clawed stone crab) – copper, lead, zinc
- AE-3: bottomfish (bandtail goatfish) – cadmium, copper, lead, mercury, zinc, total PCBs
- AE-4: waterbirds (Hawaiian stilt) – copper, lead, mercury, total PCBs

The risk to bottomfish is greater than the risk to other ecological receptors; therefore, a bottomfish was selected as the representative ecological receptor for the site. The bandtail goatfish was selected as the bottomfish species that best represents the link between sediment and fish tissue contamination due to their relatively small home range and long life span.

To evaluate risk to marine invertebrates living in the sediments (macroinfauna), potential effects on growth/development, reproduction, and survival of surrogate test organisms were evaluated in site-specific toxicity tests. Potential risks to organisms living on the sediment (epifauna), bottomfish, and waterbirds were estimated based on whole body concentrations calculated using site-specific bioaccumulation factors.

To ensure that ecological risk was based on the site-specific bioavailability of COPCs, estimates of risk were calculated in the BERA using detected concentrations in sediment and wild-caught tissue samples of marine organisms collected in 1996 for the Pearl Harbor Sediment RI. Risk estimates were calculated using a HQ methodology following guidance in DON (2003, Section 3, page 40) and EPA (1997a, page 2-4). A HQ is the ratio of a modeled or measured EPC for a COPC to an ecotoxicity reference value for an effect threshold for the COPC.

Site-Specific Bioavailability. Collocated tissue and sediment PCB data acquired during the RI Addendum investigation were used to update the estimated bioaccumulation rates and derive site-specific biota-sediment accumulation factors (BSAFs) using EPA's (2009) paired BSAF methodology. The Navy presented the new BSAF evaluation results in the RI Addendum report (DON 2013, Appendix D.1). The site-specific BSAFs, normalized to site-specific total organic carbon (TOC) concentrations in sediment and lipid concentrations in fish tissue, were used in conjunction with toxicity values for birds and fish to establish PRGs for ecological receptors that eat fish.

Metals bioavailability was assessed using acid volatile sulfide-simultaneously extracted metals (AVS-SEM) and TOC data, as described in the RI Addendum report (DON 2013). This assessment was conducted after the BERA was completed. AVS-SEM and TOC data were obtained from collocated surface sediment samples collected during the RI sampling event in 1996 and the RI Addendum sampling event in 2009. The data were evaluated for potential changes in bioavailability over the 13-year period between the two sampling events. The data indicated that the bioavailability of metals in subsurface sediments in all but 20 of the 65 Southeast Loch sediment samples from 2009 is well below levels that could cause toxic effects to benthic organisms. The data indicate that metal COCs (i.e., copper, lead, zinc) in Pearl Harbor sediments are not likely to be bioavailable to benthic organisms.

Table 2-9: Pearl Harbor Sediment COCs and Summary of Ecological Risks

COC	Potentially Unacceptable Ecological Risk [a]	AE-1: Invertebrates Living in Sediment [a]		AE-2: Invertebrates Living on Sediment [a]		AE-3: Bottomfish [a]		AE-4: Waterbird [a]	
		HQ LOAEL	ERV Endpoint	HQ LOAEL	ERV Endpoint	HQ LOAEL	ERV Endpoint	HQ LOAEL	ERV Endpoint
Antimony	No	N/A	N/A	N/A	N/A	<1	Mortality	N/A	N/A
Cadmium	Yes	<1	Growth and development	<1	Growth and development	***1.3***	Growth and development	<1	Growth and development + Reproduction
Copper	Yes	***18.7***	Growth and development	***16.9***	Growth and development	***26.3***	Mortality	***1.2***	Growth and development
Lead	Yes	***10.3***	Reproduction	***1.7***	Reproduction	***3.4***	Growth and development	***70.3***	Reproduction
Mercury	Yes	<1	Reproduction	<1	Reproduction	***8.2***	Growth and development	***7.3***	Reproduction
Zinc	Yes	***2.9***	Mortality	***1.8***	Mortality	***5.7***	Rep	<1	Reproduction
Total PCBs	Yes	***1.8***	Mortality	<1	Mortality	***64.6***	Mortality	***14.9***	Reproduction

Note: ***Bold italic value*** indicates an exceedance of the target HQ of 1.
ERV ecotoxicity reference value
LOAEL lowest-observed-adverse-effect level
N/A not applicable because chemical is a COC based on human health risk, not ecological risk.
[a] Based on BERA (DON 2007a, Appendix M).

2.7.3 Basis for Action

The response action selected in this ROD is necessary to protect the public health, welfare, or the environment from actual or threatened releases of hazardous substances into the environment.

2.8 Remedial Action Objectives

RAOs are narrative statements that define goals for protection of human health and the environment to aid in the development and evaluation of remedial alternatives and establish chemical-specific PRGs for remedial actions. The RAOs link the level or degree of cleanup required to protect human health and the environment to the risk assessment findings. The EPA (1988) RI/FS guidance states that RAOs should be as detailed as possible without limiting the range of possible remedial alternatives. The EPA RI/FS guidance specifies that RAOs are to be developed based on the results of the HHRA and BERA. Other EPA guidance (EPA 1991a, 1999) states that RAOs should specify the following:

- The exposure pathways, the receptors, and the COCs
- An acceptable chemical concentration or range of concentrations for each exposure pathway

The HHRA and BERA results suggest potential unacceptable risks for humans who consume fish and shellfish taken from the harbor, for ecological receptors exposed via dermal contact with or incidental ingestion of the sediment (e.g., invertebrates and bottomfish), and for higher-trophic-level ecological receptors exposed via consumption of fish and invertebrates caught in the harbor (e.g., waterbirds). The BERA results also indicate that the risk to bottomfish is greater than the risk to other ecological receptors for deep water areas where higher-trophic-level receptors (waterbird) cannot consume fish and/or invertebrates; therefore, RAOs developed to protect bottomfish will also be protective of invertebrates. For shallow water areas where waterbirds can be exposed to contaminated sediment, the risk to waterbirds is greater than the risk to other ecological receptors; therefore, RAO developed to protect waterbirds in shallow water areas will also be protective of other receptors.

For human health, the EPA defines a generally acceptable risk range for excess cancer risks as between one in ten thousand (1×10^{-4}) and one in one million (1×10^{-6}) (i.e., the "target risk range"), and for non-cancer risks a hazard index (HI) of 1 or less is considered acceptable (EPA 1991b). Excess cancer risks greater than 1×10^{-4} or HIs greater than 1 generally warrant a response action (EPA 1997a).

Three RAOs were developed for the Pearl Harbor Sediment site: one for protection of human health and two for protection of ecological receptors:

- Human health risk–based RAO:
  - RAO 1: Reduce human health risks associated with the consumption of harbor fish and shellfish by reducing concentrations of COCs in surface sediments to protective levels.
- Ecological risk–based RAOs:
  - RAO 2: Reduce dermal contact/incidental ingestion risks to sediment-associated fish from exposure to COCs by reducing concentrations of COCs in surface sediments to protective levels.
  - RAO 3: Reduce risks to waterbirds that forage in shallow waters in Pearl Harbor from exposure to COCs by reducing concentrations of COCs in surface sediments to protective levels.

As discussed in Section 2.7.2, achievement of RAO 2 will also lead to protection of the other ecological receptors identified for the site.

The RAOs are achieved when SWACs representing COC concentrations in a particular DU have decreased to levels at or below the PRGs. If the DU-specific SWACs for one or more COC exceed the PRGs, then remedial action is required to reduce the SWACs to levels below the PRGs. Remedial action levels (RALs) are chemical-specific, point-based sediment concentrations used to identify the locations and extent of sediments in each DU that requires remedial action. DU-wide SWACs can be decreased to levels at or below the PRGs by focusing remedial action on locations where sediment point concentrations exceed the RALs. As discussed in Section 2.8.3, the SWACs could be reduced to levels below the PRGs either immediately after implementation of the remedial action, or over time (i.e., through natural recovery) by reducing point-based concentrations in surface sediments within each DU to levels at or below the RALs.

For example, remedial action is required to reduce the SWACs for PCBs and mercury in DU SE-1 (Southeast Loch) to levels at or below the PRGs. The DU-wide SWACs representing PCBs (458 µg/kg) and mercury (1.4 mg/kg) in surface sediments within this DU exceed the PRGs (170 µg/kg and 0.71 mg/kg, respectively). Remediation of sediments with total PCB concentrations exceeding a RAL of 420 µg/kg would reduce the DU-wide SWAC for PCBs in DU SE-1 to levels below the PRG immediately following implementation of the remedy (Table 2-10).

2.8.1 Identification of Applicable or Relevant and Appropriate Requirements

CERCLA Section 121 requires remedial actions to achieve ARARs or waive them. According to the NCP (40 CFR 300.5), applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Requirements that are not applicable may be relevant and appropriate for a particular CERCLA site. Relevant and appropriate requirements are promulgated standards or requirements that are not "applicable" to the particular CERCLA site, but are well suited for the site because they address problems or situations similar to those encountered at the site. ARARs are important in the context of effectiveness and performance expectations for the remedial alternatives. Some ARARs provide numerical values that specify the acceptable amount or concentrations of chemicals that may remain in or be discharged to the environment. Other ARARs place requirements or limitations on the locations of actions and the conduct of specific actions that may be undertaken as part of a cleanup remedy (such as sediment disposal requirements).

Non-promulgated advisories or guidance documents issued by federal or state governments do not have the status of ARARs. However, these advisories and guidance are to be considered (TBC) when determining protective cleanup levels, as defined in 40 CFR 300.400 (g)(3). TBCs generally fall within three categories: health effects information or acceptable chemical concentration thresholds with a high degree of credibility; technical information on how to perform or evaluate site investigations or response actions; and agency policy or guidance.

The following three categories of ARARs and TBC criteria influence development and evaluation of RAOs and PRGs, and the selection of remedial alternatives in the FS:

- **Chemical-specific requirements** define acceptable chemical concentration thresholds for the environmental media of concern and therefore are considered in establishing PRGs, remedial goals, and RALs.
- **Location-specific requirements** set restrictions on activities within specific locations, such as floodplains or wetlands.
- **Action-specific requirements** set controls or restrictions for particular construction, operation, and disposal activities related to in-water construction or the management of hazardous wastes.

The ARARs and TBCs identified for the site are presented and discussed in Section 2.13.2 and are listed in Table 2-42.

2.8.2 Preliminary Remediation Goals

PRGs are specific endpoint concentration thresholds (or risk levels) intended to provide adequate protection of human health and the environment based on available site information (EPA 1997b). The following factors are considered to develop PRGs:

- ARAR and TBC criteria
- RBTCs developed in the risk assessments
- Background concentrations if protective RBTCs are below background concentrations

Site-specific PRGs for Pearl Harbor sediments were initially developed and presented in the RI report (DON 2007a), and subsequently revised in the RI Addendum report (DON 2013) and the FS (DON 2015). The site-specific PRG selected for each COC is set at the lowest concentration of the risk-based criteria identified for the COC, unless the criterion is below the background concentration threshold established for the COC. The site-specific PRGs were compared to the SWACs calculated for each COC to define the extent of sediments that may require remedial action.

2.8.2.1 Role of ARARs/TBCs in Developing PRGs

No promulgated federal or State of Hawaii criteria establish numerical standards that would be chemical-specific ARARs for Pearl Harbor sediment.

The DOH (2012) publication *State of Hawaii, Protocol for Developing Fish Advisories for Polychlorinated Biphenyls (PCBs)* is identified as a TBC and used to develop chemical-specific criterion for PCBs for human health protection via fish consumption pathway. In the document, DOH developed a protocol for establishing fish advisories for PCBs in fish fillets based on balancing factors including risk to human health associated with ingestion of PCBs, the health benefits of eating fish, and the presence of background levels of PCBs in commercially available fish. DOH considers the default approach by EPA's Office of Water that uses 1×10^{-5} cancer health endpoint to establish monthly fish consumption limits for carcinogens as overly restrictive and as prohibiting consumers from enjoying the benefits of fish consumption. DOH developed monthly fish consumption limits based on non-cancer endpoints. For fish tissue containing less than 20 micrograms per kilogram (µg/kg) total PCBs after filleting (based on a consumption limit of four meals per month), DOH (2012) will not recommend additional monitoring or issue an advisory for a particular water body or fish species. This concentration corresponds to a maximum cancer risk level of 2×10^{-5}. In addition, DOH establishes a "Limited Consumption" upper threshold at 190 µg/kg wet weight (ww) for fish fillet based on a consumption limit of 0.5 meal/month based on a non-cancer scenario. This threshold exceeds the 1×10^{-5} cancer-based fish tissue concentration, but is less than the 1×10^{-4} cancer risk level. The DOH recommends no fish consumption above this level in Pearl Harbor. The "Limited Consumption" threshold of 190 µg/kg ww in fish fillets was used to derive a human health risk–based criterion for total PCBs of 170 µg/kg dry weight for Pearl Harbor sediment, as presented in the *Navy Position Paper: Post-Remediation Monitoring Plan* (DON 2015, Appendix F.1).

2.8.2.2 Role of RBTCs in Developing PRGs

RBTCs are calculated sediment and tissue concentrations estimated to be protective of a particular receptor for a given exposure pathway and target risk level. Figure 2-19 presents the range of RBTCs developed in the risk assessments for various risk pathways and receptors for sediment COCs. RBTCs for human health were calculated based on various seafood consumption scenarios (DON 2013, Section 4). The risk thresholds considered excess cancer risk levels range from 10^{-4} to

10^{-6} and are applied as site-wide average concentrations. Sediment criteria protective of ecological receptors were developed based on the relationships between chemical concentrations in sediment and resident bottomfish (AE-3) in the BERA (DON 2007a, Appendix M). Ecological risk-based criteria were initially developed in the BERA for eleven chemicals (arsenic, cadmium, copper, lead, mercury, silver, zinc, total PCBs, PAHs, dieldrin, and total endosulfan) that exhibited potential for unacceptable ecological risk to bottomfish (represented by Bandtail goatfish [*Upeneus taeniopterus*]) or waterbirds (represented by the Hawaiian stilt [*Himantopus mexicanus knudseni*]) that feed on the bottomfish.

Bioaccumulation factors for total PCBs were calculated based on the 2009 collocated sediment and fish tissue data using the methodology presented in the EPA (2009) guidance *Estimation of Biota Sediment Accumulation Factor (BSAF) From Paired Observations of Chemical Concentrations in Biota and Sediment*. The calculations yielded a harbor-wide BSAF for total PCBs (3.9).

2.8.2.3 Role of Background Concentrations

CERCLA recognizes that setting numerical cleanup goals at levels below background is impractical for chemicals that occur at background concentrations exceeding risk-based or ARAR criteria. Both natural processes (e.g., deposition of naturally occurring metallic minerals in fluvial sediments) and anthropogenic processes (e.g., deposition of chemicals from internal combustion engine exhaust and highway runoff) may result in elevated concentrations of various chemicals—including hazardous substances—in otherwise unimpacted sediments. These background chemicals are derived from natural or anthropogenic sources, and are not associated with site-related chemical releases. Background is particularly important for establishing appropriate PRGs for sediment because cleanup of sediment to levels within background concentration ranges is not technically practicable or cost effective, and chemicals that occur in the surrounding watershed at background concentrations will recontaminate remediated areas. In addition, background concentration ranges must be considered to establish realistic risk reduction goals. The RI report presents estimated background concentration ranges for metals in Pearl Harbor sediment, based on the Environmental Background Analysis for Pearl Harbor Sediment conducted as part of the Pearl Harbor Sediment RI (DON 2007a, Appendix H). The analysis was conducted in accordance with Navy environmental background guidance (NAVFAC ESC 2003). It evaluated a dataset of surface (0–2 cm bswi) sediment samples collected in 219 sampling locations throughout Pearl Harbor, considering multiple lines of evidence including spatial distribution of the harbor sediment concentration data for the target metal, indications of separate populations represented by the dataset for the target metal, information and data regarding the occurrence of the target metal in the sediment source materials (rocks and stream sediments), and the geochemical characteristics of the target metal. The upper-bound background thresholds for Pearl Harbor Sediment COCs are presented along with the RBTCs on Figure 2-19. Based on background considerations, silver was eliminated from further consideration as a COC.

2.8.2.4 Selected PRGs

The sediment PRG selected for each COC is set at the lowest of the RBTC identified for the exposure pathways for humans (RAO 1), fish (RAO 2), or waterbirds (RAO 3), unless the risk-based criterion for a particular COC is below the upper bound of the site-specific sediment background concentration range established for that chemical (Figure 2-19). In that case, the upper bound of the background range is selected as the PRG for the COC:

- ***Antimony.*** The lowest RBTC is 1.6 milligrams per kilogram (mg/kg) for protection of human health based on the child subsistence scenario. This number is below the site-specific background concentration of 8.4 mg/kg; therefore, the PRG for antimony is the background concentration value of 8.4 mg/kg. This PRG achieves RAO 1 for protection of human health based on the adult recreational scenario, which is equivalent to the upper human health RBTC of 174 mg/kg. Antimony is not an ecological risk driver and not an applicable component for achieving RAO 2 and RAO 3.

- ***Cadmium***. Cadmium is not a human-health risk driver and therefore is not an applicable component for achieving RAO 1. The lowest ecological RBTC for cadmium is 2.8 mg/kg that is protective of the bottomfish receptor (RAO 2). This RBTC is below the upper-bound background concentration range; therefore, the PRG for cadmium is set at the background value of 3.2 mg/kg.
- ***Copper***. The lowest RBTC for human health (child subsistence, non-carcinogenic) and the RBTCs for ecological receptors (bottomfish and waterbird for shallow-water locations) are below the upper-bound background concentration; therefore, the PRG for copper is the upper-bound background concentration of 214 mg/kg. This PRG achieves the human-health RAO 1 based on the adult recreational scenario.
- ***Lead***. Lead is not a human-health risk driver and therefore not an applicable component for achieving RAO 1. The lowest RBTC for lead is the ecological threshold for protection of waterbirds applicable to shallow-water locations, which is below the background threshold. Therefore, the PRG for shallow-water locations is the upper-bound background value of 119 mg/kg. For deep-water locations where RAO 3 is not applicable, the PRG selected is to achieve ecological RAO 2 the ecological risk–based threshold protective of bottomfish of 163 mg/kg.
- ***Mercury***. Mercury is not a human-health risk driver and not an applicable component for achieving RAO 1. The lowest RBTC for mercury is the waterbird threshold (RAO 3), which is below the upper-bound background concentration. Therefore, the PRG for shallow-water locations to address RAO 3 is the upper-bound background concentration of 0.71 mg/kg. For deep-water locations where protection of waterbirds is not applicable, the PRG is the risk-based threshold protective of bottomfish (1.3 mg/kg).
- ***Zinc.*** Zinc is not a human-health risk driver and not an applicable component to achieve RAO 1. The lowest RBTC is the risk-based threshold protective of bottomfish (RAO 2), which is below the background threshold. Therefore, the selected PRG is the upper-bound background value of 330 mg/kg. This PRG is protective of the waterbird receptor (RAO 3).
- ***Total PCBs***. Total PCBs is a risk-driver for both human health and ecological risks. The PRG developed for protection of human receptors exposed via the fish consumption pathway is based on the DOH (2012) fish advisory level. Two PRGs were developed for total PCBs, one for areas with water depths greater than 6 feet (2.2 meters) and one for areas with water depths less than or equal to 6 feet (2.2 meters). The PRG for deep water areas is 170 µg/kg, which corresponds to a fish tissue fillet concentration of 190 µg/kg ww based on the DOH fish advisory level for limited fish consumption, i.e., up to one 4-ounce (113-gram) serving per month. The DOH advisory for PCBs (2012) considers the unique health benefits associated with fish consumption. The fish advisory protocol is based on the non-cancer endpoint to allow consumers to enjoy the numerous health benefits of eating fish. RAO 1 (human health) and RAO 2 (bottomfish) will be achieved when the SWACs for total PCBs in deep water areas have decreased to levels at or below the deep-water sediment PRG (170 µg/kg). RAO 3 (waterbirds) will be achieved when the SWACs for total PCBs in shallow water areas (applicable only to DU E-2) have decreased to levels at or below the shallow-water sediment PRG (110 µg/kg).

2.8.3 Remedial Action Levels

RALs are chemical-specific, point-based sediment concentrations developed to determine the extent of sediments that will require remediation to decrease SWACs to levels at or below the PRGs and thus achieve the RAOs. Whereas PRGs are the long-term cleanup goals for the site, RALs are applicable for the short term to determine where remediation is required to meet the long-term goals. PRGs are generally compared to average concentrations (e.g., SWACs) representing the entire DU or exposure area of concern, whereas RALs are compared to sample results on a point-by-point basis; therefore, the RALs are higher than the PRGs. For COCs with PRGs set at background levels (i.e., all metals included in the Pearl Harbor Sediment site COC list), the RALs must exceed the PRGs, as cleanup to background levels on a point-by-point basis is not feasible. An array of RALs was developed based on the premise that the SWACs for applicable COCs will be considerably lower compared to baseline conditions once active remediation is completed. The following array of RALs was developed to achieve the PRGs either immediately after implementation or over time through natural recovery:

- RAL_0 criteria, developed using DU-specific data distribution, are the lowest RALs developed for each DU, and represent not-to-exceed concentrations predicted to achieve DU-wide SWACs below the PRGs after remedial construction is complete.
- RAL_{10} criteria, developed using DU-specific natural recovery modeling (DON 2015, Appendix D), represent not-to-exceed concentrations predicted to achieve DU-wide SWACs below the PRGs within 10 years after remedial construction is complete.
- RAL_{20} criteria, developed using DU-specific natural recovery modeling (DON 2015, Appendix D), represent not-to-exceed concentrations predicted to achieve DU-wide SWACs below the PRGs within 20 years after remedial construction is complete. RAL_{20} criteria were developed for DU SE-1 to support integrating ongoing natural recovery as a component of remedial alternatives that are potentially more cost-effective to address the large volume of contaminated sediments and relatively high COC concentrations in this DU.

Development of RAL_0 is based on an iterative process to determine the maximum concentration, or the “do-not-exceed” value that will result in reduction of the SWAC to meet the selected PRGs and achieve all applicable RAOs immediately following construction. Thiessen polygons were generated around individual surface sediment sampling locations from 2009 and 2012 field investigations. The surface sediment concentration reported for each sampling location was assumed to represent the surface sediment for the whole area located within each polygon, and the DU-wide SWAC was then calculated and compared to the PRG. For COCs that exceed the PRGs, an initial “do-not-exceed” concentration was selected as a starting value for the RAL calculation. All areas above that concentration were assumed to be remediated and will have a replacement surface sediment concentration that will be lower than the RAL value. The replacement surface sediment value could range from zero (i.e., non-detect) up to the RAL value. For the purpose of the FS, an intermediate value was selected as the replacement surface sediment value, which is half he RAL concentration. However, if half the RAL was below background values, the replacement value was set to background. For clean sand to be used as cap material, concentrations of COCs would be expected to be below these values. The SWAC was then recalculated and compared to the PRG. If the new SWAC was below the PRG, then the RAL was selected. If the new SWAC exceeded the PRG, then the process was repeated by lowering the RAL until the resulting SWAC met the PRGs.

RAL_{10} and RAL_{20} criteria were developed specifically for DUs with large remediation footprints (e.g., DU SE-1) to develop more feasible remedial alternatives focusing on addressing areas with high levels of contamination first with the primary technology (e.g., dredging or capping) combined with natural recovery-based technologies (e.g., MNR and/or ENR) and in-situ treatment application for the lower-level contamination to reach the PRGs within 10 or 20 years. RAL_{10} is the concentration that reaches RAL_0 (and, therefore, the area-wide PRG) in 10 years in areas with average conditions (e.g., average sedimentation), and RAL_{20} is the concentration that reaches RAL_0 (and, therefore, the area-wide PRG) in 20 years. Remedial alternatives based on RAL_{10} or RAL_{20} achieve the same level of protectiveness as RAL_0-based alternatives through natural recovery within 10 or 20 years.

Table 2-10 – Table 2-12 summarize the results of development of RAL_0, RAL_{10}, and RAL_{20}, respectively, for the DUs being evaluated for remediation of sediments. Sub-areas within the DUs that exceed the RALs are identified as areas to be considered for active remediation to reduce the DU-wide risk to meet the RAOs and the PRGs.

2.8.3.1 DU SE-1 (Southeast Loch) RALs

All COCs for DU SE-1 have SWACs exceeding the PRGs. RALs were not developed for copper and lead because their SWACs only slightly exceed the PRGs. RALs developed to address the more widespread mercury and total PCB concentrations should also address and reduce the concentrations for copper and lead needed to meet the PRGs and achieve RAO 1 (human health) and RAO 2 (bottomfish). RAO 3 (waterbird) is not applicable for DU SE-1 based on limited presence of shallow-water areas providing suitable habitat for waterbirds.

The RALs selected for DU SE-1 sediments and the predicted short-term and long-term outcomes are as follows:

- **RAL_0:** The following action levels (Table 2-10) will reduce the SWAC for all COCs to achieve PRGs and applicable RAOs in the short term (post-implementation of the remedy):
  - **Mercury RAL_0:** 1.3 mg/kg. This action level will achieve RAO 2 (bottomfish) following implementation by reducing the SWAC from 1.4 mg/kg to 0.66 mg/kg, below the PRG of 0.71 mg/kg. RAO 1 (human health) is not applicable for mercury.
  - **Total PCB RAL_0:** 420 µg/kg. This action level will achieve both RAO 1 (human health) and RAO 2 (bottomfish) following implementation by reducing the SWAC from 458 µg/kg to 167 µg/kg, which is below the PRG of 170 µg/kg.
- **RAL_{10}:** The following action levels (Table 2-11) are predicted to meet PRGs and achieve all applicable RAOs within 10 years following implementation of the remedy:
  - **Mercury RAL_{10}:** 2.1 mg/kg. This action level will achieve RAO 2 (bottomfish) in the short term by reducing the SWAC from 1.4 mg/kg to 0.91 mg/kg to meet the risk-based threshold protective of bottomfish (1.3 mg/kg). This action level relies on natural recovery to further reduce the SWAC to meet the background-based PRG of 0.71 mg/kg within 10 years following implementation.
  - **Total PCB RAL_{10}:** 740 µg/kg. This action level will achieve RAO 2 (bottomfish) in the short term, and RAO 1 (human-health) in the long term via natural recovery. The post-implementation SWAC of 254 µg/kg meets the threshold protective of bottomfish (470 µg/kg), thus achieving RAO 2 (bottomfish) in the short term. Continued natural recovery is predicted to further reduce the post-implementation SWAC (254 µg/kg) to meet the PRG of 170 µg/kg to achieve RAO 1 (human health) within 10 years.
- **RAL_{20}:** The following action levels (Table 2-12) are predicted to meet PRGs and all applicable RAOs within 20 years following implementation of remedy:

- **Mercury RAL_{20}:** 4 mg/kg. This action level will achieve RAO 2 (bottomfish) in the short term by reducing the SWAC from 1.4 mg/kg to 1.1 mg/kg to meet the risk-based threshold protective of bottomfish (1.3 mg/kg). This action level relies on natural recovery to further reduce the SWAC to meet the background-based PRG of 0.71 mg/kg within 20 years following implementation.
- **Total PCB RAL_{20}:** 1,300 µg/kg. This action level will achieve RAO 2 (bottomfish) in the short term, and RAO 1 (human-health) in the long term via natural recovery. The post-implementation SWAC of 317 µg/kg meets the threshold protective of bottomfish (470 µg/kg), thus, achieving RAO 2 (bottomfish) in the short term. Continued natural recovery is predicted to further reduce the post-implementation SWAC (317 µg/kg) to meet the PRG of 170 µg/kg to achieve RAO 1 (human health) within 20 years.

2.8.3.2 DU N-2 (Oscar 1 and 2 Piers Shoreline) RALs

- **RAL_0:** The following action levels (Table 2-10) will reduce the SWAC for all COCs to achieve PRGs and all applicable RAOs in the short term:
  - **Mercury RAL_0:** 1.4 mg/kg. This action level will achieve RAO 2 (bottomfish) in the short term by reducing the SWAC from 1.2 mg/kg to 0.70 mg/kg post-implementation. RAO 1 (human health) is not applicable for mercury.
  - **Total PCB RAL_0:** 380 µg/kg. This action level will achieve both RAO 1 (human health) and RAO 2 (bottomfish) by reducing the SWAC from 329 µg/kg to 168 µg/kg to meet the PRG of 170 µg/kg for RAO 1 (human health).
- **RAL_{10}:** The following action levels (Table 2-11) are predicted to meet PRGs and achieve all applicable RAOs within 10 years following implementation of the remedy:
  - **Mercury RAL_{10}:** 2.3 mg/kg. This action level will achieve RAO 2 (bottomfish) in the short term by reducing the SWAC from 1.2 mg/kg to 0.88 mg/kg to meet the risk-based threshold protective of bottomfish (1.3 mg/kg). This action level relies on natural recovery to reduce the post-implementation SWAC of 0.88 mg/kg to meet the background-based PRG of 0.71 mg/kg within 10 years.
  - **Total PCB RAL_{10}:** 670 µg/kg. This action level will achieve RAO 2 (bottomfish) in the short term, and RAO 1 (human-health) in the long term via natural recovery. Post-implementation SWAC of 325 µg/kg meets the threshold protective of bottomfish (470 µg/kg), thus, achieving RAO 2 (bottomfish) in the short term. Continued natural recovery is predicted to further reduce the post-implementation SWAC (325 µg/kg) to meet the PRG of 170 µg/kg to achieve RAO 1 (human health) within 10 years.

2.8.3.3 DU N-3 (Off Ford Island Landfill) RALs

Total PCBs is the only COC identified for DU N-3. The following RAL is selected for DU N-3 sediments to achieve RAO 1 (human health) and RAO 2 (bottomfish); RAO 3 (waterbird) is not applicable to DU N-3 due to the rocky, rip-rap shoreline being unsuitable as a foraging area for waterbirds:

- **Total PCB RAL_0:** 470 µg/kg (Table 2-10). This action level will achieve both RAO 1 (human health) and RAO 2 (bottomfish) in the short term by reducing the baseline SWAC of 213 µg/kg to 133 µg/kg to meet the PRG of 170 µg/kg post-implementation.

Model-derived RAL_{10} is not developed for DU N-3 because of limited extent of contamination.

2.8.3.4 DU N-4 (Bishop Point) RALs

DU N-4 COCs with point concentrations above PRGs are antimony, lead, mercury, and zinc. However, only lead and zinc have SWACs that exceed the PRGs. Point concentration exceedances of the PRGs are not collocated for lead and zinc; therefore, a single independent RAL was developed for each COC with a SWAC exceedance in DU N-4 sediments to achieve RAO 2; RAO 1 is not applicable to DU N-4 because both lead and zinc are ecological risk drivers, and RAO 3 is not applicable due to limited availability of shallow areas within the DU for waterbirds to forage. The following RALs are selected for DU N-4 sediments:

- **RAL_0:** The following action levels will reduce the SWAC for all COCs to achieve PRGs and the only applicable RAO 2 (bottomfish) in the short term:
  - **Lead RAL_0:** 420 mg/kg. This action level will achieve RAO 2 (bottomfish) immediately following implementation by reducing the SWAC from 664 mg/kg to 118 mg/kg to meet the PRG of 119 mg/kg.
  - **Zinc RAL_0:** 1,200 mg/kg. This action level will achieve RAO 2 (bottomfish) immediately following implementation by reducing the SWAC from 381 mg/kg to 293 mg/kg to meet the PRG of 330 mg/kg.
- **RAL_{10}:** The following action level is predicted to meet PRGs in 10 years following implementation of the remedy for lead:
  - **Lead RAL_{10}:** 740 mg/kg. This action level will achieve RAO 2 (bottomfish) immediately following implementation by reducing the SWAC to 139 mg/kg, which meets the deep-water PRG of 163 mg/kg. Risk reduction via natural recovery is expected to continue by reducing the post-implementation SWAC of 139 mg/kg to meet the background-based PRG of 119 mg/kg within 10 years.
  - **Zinc RAL_{10}:** 2,000 mg/kg. This action level will achieve RAO 2 (bottomfish) within 10 years via natural recovery.

2.8.3.5 DU E-2 (Off Waiau Power Plant) RALs

Total PCBs is the only COC for DU E-2. Because the DU's water depths are primarily less than 2 meters (6.6 feet), the area-wide SWAC was compared to the PRG of 110 µg/kg, the RBTC developed for protection of the waterbird ecological receptor from exposure to PCBs via consumption of bottomfish. This PRG is also protective of human health and bottomfish; therefore, the following RALs selected for DU E-2 sediments are designed to achieve all RAOs:

- **Total PCBs RAL_0:** 270 µg/kg. This action level will achieve all RAOs in the short term by reducing the SWAC from 938 µg/kg to 108 µg/kg post-implementation and meet the shallow-water PRG of 110 µg/kg (RAO 3) following implementation of the remedy.
- **Total PCBs RAL_{10}:** 470 µg/kg. This action level will achieve RAO 2 (bottomfish) in the short term and rely and natural recovery to achieve RAO 1 (human health) and RAO 3 (waterbird) in the long term within 10 years following implementation. The post-implementation SWAC of 196 µg/kg meets the risk-based threshold protective of bottomfish of 470 µg/kg to achieve RAO 2 (bottomfish). Continued natural recovery is expected to reduce the post-implementation SWAC of 196 µg/kg to meet the PRG (110 µg/kg) within 10 years following implementation of the remedy.

2.8.3.6 DU E-3 (AIEA BAY) RALS

Lead, mercury, and zinc are the COCs identified for DU E-3, with mercury as the only COC with SWAC above the PRGs. Mercury is not a human health risk driver; therefore, RAO 1 (human health) is not applicable to DU E-3. Both shallow- and deep-water areas are present in DU E-3; therefore, the following RAL is developed for mercury to achieve RAO 2 (bottomfish) and RAO 3 (waterbird):

- **Mercury RAL_0:** 1.7 mg/kg. This will reduce the SWAC to 0.67 mg/kg post remediation, thereby, achieving the selected PRG of 0.71 mg/kg based on the background concentration. No upper RAL is developed for mercury in DU E-3 because the initial SWAC of 1.1 mg/kg is already below the ecological RBTC of 1.3 mg/kg that is protective of exposure to mercury in sediment by the bottomfish receptor via direct exposure.

Table 2-10: Sediment RAL_0 for the Six Remediation DUs

			Pre-Remedy Concentration			Post-Remedy Concentration			
DU	COC	PRG	Max	SWAC	RAL_0 [a]	SWAC	Max	Applicable RAO(s) [b]	Goal/Outcome
SE-1 (Southeast Loch)	***Copper (mg/kg)***	214	3,960	***230***	—	—	—	1, 2	RAL is not developed for the COC; PRG will be met by achieving the RAL(s) developed for other more widespread COC(s).
	Lead (mg/kg)	119 [c] 163 [d]	1,010	***121***	—	—	—	2	
	Mercury (mg/kg)	0.71 [c] 1.3 [d]	12.3	***1.4***	1.3	0.66	1.3	2	Reduce SWAC to meet PRG and achieve RAO 2 (bottom fish).
	Total PCBs (µg/kg)	170 [d]	18,000	***458***	420	167	410	1, 2	Reduce SWAC to meet PRG and achieve RAO 1 (human health) and RAO 2.
N-2 (Oscar 1 and 2 Piers Shoreline)	Cadmium (mg/kg)	3.2	21.5	1.8	—	—	—	2	SWAC is below the PRG; RAL is not developed for COC.
	Copper (mg/kg)	214	792	207	—	—	—	1, 2	
	Lead (mg/kg)	119 [c] 163 [d]	302	107	—	—	—	2	
	Mercury (mg/kg)	0.71 [c] 1.3 [d]	4.6	***1.2***	1.4	0.70	1.3	2	Reduce SWAC to meet PRG and achieve RAO 2.
	Zn (mg/kg)	330	805	316	—	—	—	2	SWAC is below the PRG; RAL is not developed for COC.
	Total PCBs (µg/kg)	170 [d]	1,000	***330***	380	168	348	1, 2	Reduce SWAC to meet PRG and achieve RAO 1 and RAO 2.
N-3 (Off Ford Island Landfill and Camel Refurbishing Area)	***Total PCBs (µg/kg)***	170 [d]	1,700	***213***	470	133	240	1, 2	Reduce SWAC to meet PRG and achieve RAO 1 and RAO 2.
N-4 (Bishop Point)	Antimony (mg/kg)	8.4	29.8	5.9	—	—	—	1, 2	SWAC is below the PRG; RAL is not developed for COC.
	Lead (mg/kg)	119 [c] 163 [d]	4,110	***664***	420	118	415	2	Reduce SWAC to meet PRG and achieve RAO 2.
	Mercury (mg/kg)	0.71 [c] 1.3 [d]	0.79	0.3	—	—	—	1, 2	SWAC is below the PRG; RAL is not developed for COC.
	Zinc (mg/kg)	330	1,280	***381***	1,200	293	920	2	Reduce SWAC to meet PRG post-implementation.
E-2 (Off Waiau Power Plant)	***Total PCBs (µg/kg)***	110 [c]	4,200	***938***	270	108	265	1, 2, 3	Reduce SWAC to meet PRG and achieve RAO 1, RAO 2, and RAO 3 (waterbird).

Table 2-10: Sediment RAL_0 for the Six Remediation DUs

DU	COC	PRG	Pre-Remedy Concentration		RAL_0 [a]	Post-Remedy Concentration		Applicable RAO(s) [b]	Goal/Outcome
			Max	SWAC		SWAC	Max		
E-3 (Aiea Bay)	Lead (mg/kg)	119 [c] 163 [d]	140	53	—	—	—	2, 3	SWAC is below the PRG; RAL is not developed for COC.
	Mercury (mg/kg)	0.71 [c] 1.3 [d]	2.4	***1.1***	1.7	0.67	1.6	2, 3	Reduce SWAC post-implementation to meet PRG and achieve RAO 2 and RAO 3.
	Zn (mg/kg)	330	626	297	—	—	—	2, 3	SWAC is below the PRG; RAL is not developed for COC.

Notes: ***Bold italic font*** indicates COC with SWAC exceeding the PRG.
— RAL not developed: SWAC is below PRG, or PRG will be met by achieving the RAL(s) developed for other COC(s).
[a] RAL_0 is designed to achieve PRGs in the short term (i.e., following implementation of the remedy).
[b] RAO 1 is applicable to COCs that are human-health risk drivers (antimony, copper, total PCBs). RAO 2 and RAO 3 are applicable to COCs that are ecological risk drivers (cadmium, copper, lead, mercury, zinc, total PCBs). RAO 3 is applicable only to DU E-2 and E-3 where shallow-water areas are present for waterbirds to access sediment or consume bottomfish.
[c] Shallow-water PRG (water depth less than 2 meters [6.6 feet]).
[d] Deep-water PRG (water depth 2 meters [6.6 feet] or greater).

Table 2-11: Sediment RAL_{10} for the Six Remediation DUs

DU	COC	PRG	Pre-Remedy Concentration		RAL_{10} [a]	Post-Remedy Concentration		Appli-cable RAO(s) [b]	Goal/Outcome
			Max	SWAC		SWAC	Max		
SE-1 (Southeast Loch)	***Copper (mg/kg)***	214	3,960	***230***	—	—	—	1, 2	RAL is not developed for the COC; PRG will be met by achieving the RAL(s) developed for other more widespread COC(s).
	Lead (mg/kg)	119 [c] 163 [d]	1,010	***121***	—	—	—	2	
	Mercury (mg/kg)	0.71 [c] 1.3 [d]	12.3	***1.4***	2.1	0.91	1.9	2	**Short-Term:** Reduce SWAC to meet deep-water PRG protective of bottomfish (HQ <1; 1.3 mg/kg) and achieve RAO 2 (bottomfish). **Long-Term:** Reduce SWAC to meet background-based PRG (0.71 mg/kg) in 10 years via natural recovery.
	Total PCBs (µg/kg)	170 [d]	18,000	***458***	740	***254***	720	1, 2	**Short-Term:** Reduce SWAC to meet RBTC protective of bottomfish (470 µg/kg) and achieve RAO 2. **Long-Term:** Reduce SWAC post-implementation to meet PRG and achieve RAO 1 (human health) in 10 years.

Table 2-11: Sediment RAL_{10} for the Six Remediation DUs

DU	COC	PRG	Pre-Remedy Concentration		RAL_{10} [a]	Post-Remedy Concentration		Applicable RAO(s) [b]	Goal/Outcome
			Max	SWAC		SWAC	Max		
N-2 (Oscar 1 and 2 Piers Shoreline)	Cadmium (mg/kg)	3.2	21.5	1.9	—	—	—	2	SWAC is below the PRG; RAL is not developed for COC.
	Copper (mg/kg)	214	792	207	—	—	—	1, 2	
	Lead (mg/kg)	119 [c] 163 [d]	302	108	—	—	—	2	
	Mercury (mg/kg)	0.71 [c] 1.3 [d]	4.6	***1.2***	2.3	***0.88***	1.9	2	**Short-Term:** Reduce SWAC to meet deep-water PRG protective of bottomfish (HQ <1; 1.3 mg/kg) and achieve RAO 2. **Long-Term:** Reduce SWAC post-implementation to meet PRG in 10 years.
	Zn (mg/kg)	330	805	316	—	—	—	2	SWAC is below the PRG; RAL is not developed for COC.
	Total PCBs (µg/kg)	170 [d]	1,000	***329***	670	***325***	670	1, 2	**Short-Term:** Reduce SWAC to meet RBTC protective of bottomfish (470 µg/kg) and achieve RAO 2 (bottomfish). **Long-Term:** Reduce SWAC post-implementation to meet PRG and achieve RAO 1 in 10 years.
N-3 (Off Ford Island Landfill and Camel Refurbishing Area)	***Total PCBs (µg/kg)***	170 [d]	1,700	***213***	—	—	—	—	RAL_{10} is not developed for the COC because of the limited extent of contamination in the DU.
N-4 (Bishop Point)	Antimony (mg/kg)	8.4	29.8	5.9	—	—	—	1, 2	SWAC is below the PRG; RAL is not developed for COC.
	Lead (mg/kg)	119 [c] 163 [d]	4,110	***664***	740	139	415	2	Reduce SWAC to meet PRG and achieve RAO 2.
	Mercury (mg/kg)	0.71 [c] 1.3 [d]	0.79	0.3	—	—	—	1, 2	SWAC is below the PRG; RAL is not developed for COC.
	Zinc (mg/kg)	330	1,280	***381***	2,000	—	—	2	Reduce SWAC to meet PRG post-implementation.
E-2 (Off Waiau Power Plant)	***Total PCBs (µg/kg)***	110 [c]	4,200	***938***	470	196	420	1, 2, 3	**Short-Term:** Reduce SWAC to meet risk-based threshold protective of bottomfish (470 µg/kg) and achieve RAO 2. **Long-Term:** Reduce SWAC to meet PRG and achieve RAO 1 (human health) and RAO 3 (waterbird) in 10 years.

Table 2-11: Sediment RAL_{10} for the Six Remediation DUs

DU	COC	PRG	Pre-Remedy Concentration Max	Pre-Remedy Concentration SWAC	RAL_{10} [a]	Post-Remedy Concentration SWAC	Post-Remedy Concentration Max	Applicable RAO(s) [b]	Goal/Outcome
E-3 (Aiea Bay)	Lead (mg/kg)	119 [c] 163 [d]	140	53	—	—	—	2, 3	SWAC is below the PRG; RAL is not developed for COC.
	Mercury (mg/kg)	0.71 [c] 1.3 [d]	2.4	***1.1***	—	—	—	2, 3	RAL_{10} is not selected for the COC because it would be above the maximum concentration in the DU.
	Zn (mg/kg)	330	626	297	—	—	—	2, 3	SWAC is below the PRG; RAL is not developed for COC.

Notes: ***Bold italic font*** indicates COC with SWAC exceeding the PRG.
— RAL not developed: SWAC is below PRG, or PRG will be met by achieving the RAL(s) developed for other COC(s).
[a] RAL_{10} is designed to achieve PRGs in 10 years following implementation.
[b] RAO 1 is applicable to COCs that are human-health risk drivers (antimony, copper, total PCBs). RAO 2 and RAO 3 are applicable to COCs that are ecological risk drivers (cadmium, copper, lead, mercury, zinc, total PCBs). RAO 3 is applicable only to DU E-2 and E-3 where shallow-water areas are present for waterbirds to access sediment or consume bottomfish.
[c] Shallow-water PRG (water depth less than 2 meters [6.6 feet]).
[d] Deep-water PRG (water depth 2 meters [6.6 feet] or greater).

Table 2-12: Sediment RAL_{20} for DU SE-1 (Southeast Loch)

DU	COC	PRG	Pre-Remedy Concentration Max	Pre-Remedy Concentration SWAC	RAL_{20} [a]	Post-Remedy Concentration SWAC	Post-Remedy Concentration Max	Applicable RAO(s) [b]	Goal/Outcome
SE-1 (Southeast Loch)	***Copper (mg/kg)***	214	3,960	***230***	—	—	—	1,2	RAL is not developed for the COC; PRG will be met by achieving the RAL(s) developed for other more widespread COC(s).
	Lead (mg/kg)	119 [c] 163 [d]	1,010	***121***	—	—	—	2	RAL is not developed for the COC.
	Mercury (mg/kg)	0.71 [c] 1.3 [d]	12.3	***1.4***	4	1.1	3.3	2	**Short-Term:** Reduce SWAC to meet deep-water PRG protective of bottomfish (HQ <1; 1.3 mg/kg) and achieve RAO 2 (bottomfish). **Long-Term:** Reduce SWAC post-implementation to meet background-based PRG (0.71 mg/kg) in 20 years via natural recovery.
	Total PCBs (µg/kg)	170 [d]	18,000	***458***	1,300	***317***	1,300	1, 2	**Short-Term:** Reduce SWAC to meet ecological risk–based threshold protective of bottomfish (470 µg/kg) and achieve RAO 2. **Long-Term:** Reduce SWAC post-implementation to meet PRG and achieve RAO 1 (human health) in 20 years.

Notes: ***Bold italic font*** indicates COC with SWAC exceeding the PRG.
— RAL not developed: SWAC is below PRG, or PRG will be met by achieving the RAL(s) developed for other COC(s).
[a] RAL_{20} is designed to achieve PRGs in 20 years following implementation of the remedy.
[b] RAO 1 is applicable to COCs that are human-health risk drivers (antimony, copper, total PCBs). RAO 2 and RAO 3 are applicable to COCs that are ecological risk drivers (cadmium, copper, lead, mercury, zinc, total PCBs).
[c] Shallow-water PRG (water depth less than 2 meters [6.6 feet]).
[d] Deep-water PRG (water depth 2 meters [6.6 feet] or greater).

2.9 DESCRIPTION OF RESPONSE ACTION ALTERNATIVES

This section describes the process used to develop alternatives for remedial action in each of the six DUs, the alternative evaluation process itself, and the alternative selected as the remedy for the Pearl Harbor Sediment site. Detailed evaluation of the remedial action alternatives and the rationale for recommending the alternatives as the selected remedy for each DU are presented in the FS report (DON 2015).

Remedial technologies were screened to identify general response actions (GRAs) and process options that could serve as components of remedial alternatives for the site. GRAs are broad categories of remedial actions such as removal or containment; process options are alternatives for ancillary technologies that may be used to implement the GRAs. GRAs were identified and screened (Table 2-13) in accordance with EPA's (1988) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. The following GRAs were retained for use as components of the potentially feasible remedial alternatives developed for each of the six Pearl Harbor DUs identified for sediment remediation:

- No Action was retained as required by CERCLA
- Institutional Controls (ICs) was retained as a component of a remedy
- MNR and ENR were retained because natural recovery is occurring in Pearl Harbor based on available data
- In-situ Containment (e.g., conventional capping) is likely feasible for some DUs
- In-situ Treatment (e.g., AC amendment) is likely feasible for some DUs
- Removal of contaminated sediments by dredging or excavation is likely to be feasible for some DUs
- Monitoring would be required both during and after remediation of Pearl Harbor sediments

Ancillary technologies retained for further evaluation as process options include sediment resuspension and dispersion control, post-dredging residuals control, sediment dewatering and wastewater treatment, mechanical and hydraulic sediment transportation options, and the following options for disposal of material dredged or excavated from the harbor:

- An onsite confined aquatic disposal cell within Pearl Harbor (e.g., in East Loch)
- Existing Subtitle D landfill on Oahu or the mainland
- .Existing Subtitle C landfill on the mainland
- Open-water disposal at the offshore SOODMDS
- Beneficial use within Pearl Harbor or at upland locations

The GRAs and process options retained were assembled to develop a suite of alternatives that may be feasible for one or more of the six DUs identified for sediment remediation. Although a wide range of GRAs and process options were retained, the potentially feasible remedial alternatives developed for further screening are referred to as MNR, ENR, in-situ treatment with AC amendment, capping, dredging, and combinations of these general actions. A total of 13 remedial alternatives were identified and evaluated to determine those that should be retained to develop the most feasible remedial alternatives for each of the six DUs. The retained remedial alternatives were initially screened for effectiveness, implementability, and cost in accordance with EPA's guidance (EPA 1988). Table 2-14 presents the results of the initial screening process.

Table 2-13: Technologies Retained for Development of Remedial Alternatives for Pearl Harbor Sediment

GRA	Technology Type	Process Option	Description	Screening Comments
No Action	None	Not Applicable	The NCP requires evaluation of the No Action alternative to establish a baseline for screening the remedial alternatives.	Retained for comparison to other alternatives as required by the NCP.
ICs	Access and Resource Restrictions	Land/Waterways Use and Access Restrictions	Access controls to the shoreline via land and Pearl Harbor Waterways to limit access to contaminated sediment and catching/consumption of contaminated fish or shellfish from the harbor.	IC boundaries include all submerged areas of Pearl Harbor. The Navy owns and controls access to all submerged areas of Pearl Harbor and most of the surrounding shoreline with no changes in ownership or control of the property expected in the foreseeable future. DOH has published a fish consumption advisory, distributed literature to the public, and posted advisory signs along the shoreline warning against fish consumption. ICs are readily implementable and cost-effective given currently in-place access restrictions and security measures as well as fish advisory dissemination measures. ICs would be effective at preventing unacceptable risk to human receptors to access contaminated sediments or human consumption of seafood from affected areas especially when combined with active remediation.
		Seafood Consumption Advisories, Education, and Public Outreach	Fish consumption advisory issued by the DOH advising the public to not consume fish or crabs caught in the harbor to limit consumption of contaminated fish. Distribution of leaflets and other informational materials and placement of warning signs along the shoreline.	
MNR and ENR	MNR	MNR	Monitoring of natural recovery process to assess progress towards achieving RAOs. Natural recovery process for Pearl Harbor primarily includes natural sedimentation burying contaminated sediments over time. Other physical, chemical, and biological processes may contribute to recovery.	Sediment transport evaluation support depositional nature of all DUs. Readily implementable for areas outside the maintenance dredging footprint. Implementation within maintenance dredging footprint requires combination with other remedial alternatives (e.g., dredging, ICs). Effective technology given the low mobility of COCs at the site due to sorption/sequestration and metal precipitation processes combined with overall stable and depositional environment of the site. A relatively low cost alternative compared to others; however, monitoring costs to confirm long-term effectiveness can be appreciable.
	ENR	Thin-layer Clean Material Placement	Facilitating natural recovery processes by placing a thin layer of clean media to enhance natural sedimentation, followed by monitoring to assess progress towards achieving RAOs.	
In-situ Containment	Capping	Barrier Caps	Placement of granular materials (e.g., sand/clay or mineral-based materials), usually 1–3 feet thick on top of contaminated sediment to limit mobility of COCs from migrating into the surface sediment and water and reduce bioaccessibility of COCs to burrowing organisms.	Implementable and likely effective at the site except in areas with steep slopes (e.g., near and under piers) and soft fine-grained sediments. For areas within the maintenance dredging footprint, may require combination of dredging to ensure cap emplacement is well below the dredging requirement. Armored cap may also be required in these areas to maintain integrity of the cap during potential overdredging activities. Cost is moderate but generally much lower compared to removal actions.
		Armored Caps	Placement of stone or other rip-rap over the primary capping material to stabilize cap materials in higher-energy environments or for areas within maintenance dredging requirements.	
In-situ Treatment	Treatment	AC	Placement and mixing of AC onto/into contaminated sediment to bind hydrophobic organic chemicals (e.g., PCBs) and reduce bioavailability.	Innovative technology that is effective to limit bioaccumulation based on laboratory and field testing, specifically to hydrophobic chemicals and metals such as those present as COCs at the site. AC in-situ treatment is likely implementable for most DUs in Pearl Harbor and potentially effective pending results of site-specific pilot study. This technology may also be effective for under-pier areas where access restriction may limit application of other technologies.

Table 2-13: Technologies Retained for Development of Remedial Alternatives for Pearl Harbor Sediment

GRA	Technology Type	Process Option	Description	Screening Comments
Removal	Dredging	Mechanical Dredging	Removal of contaminated sediment via mechanical dredging.	Readily implementable in areas already subject to routine maintenance dredging. Coordination with pre-existing maintenance dredging program may improve the efficiency and effectiveness of application of the technology at the site. Cost of sediment removal is relatively low; however, post-removal sediment handling, treatment, and disposal can result in moderate to high total cost for the technology due to limited disposal options and additional safety requirements for potential to encounter UXO.
		Hydraulic Dredging	Removal of contaminated sediment in a slurry form.	
	Excavation	Dry Excavation	Removal of sediments in shallow nearshore areas by dewatering (e.g., coffer dam) and using earthmoving equipment.	Readily implementable in shallow nearshore areas with upland access. Cost of sediment removal is relatively low; however, post-removal sediment handling, treatment, and disposal can result in moderate to high total cost for the technology.
Monitoring	Monitoring	Baseline Monitoring	Baseline monitoring prior to remedy application; may include bathymetry survey and sampling to characterize pre-remedy conditions.	Routinely implemented as a component of all remedial technologies considered in this FS and necessary to provide data required for five-year reviews to confirm the protectiveness of the remedial alternative selected and emplaced.
		Construction Monitoring	Monitoring implemented during remedial activities for construction controls.	
		Post-Construction Performance Monitoring	Post-construction monitoring to evaluate the effectiveness of the remedy.	
		Long-Term O&M Monitoring	Implemented for locations where contaminated sediments are left in place such as capped, treated areas, for monitoring progress of natural recovery in areas of relatively low contamination.	
Management of Removed Sediments	Dewatering	Passive	Passive dewatering using natural processes (e.g., gravity settling, evaporation). Placing sediments in detention basins or tanks to allow sediments to settle and supernatant liquid to dry via evaporation. Alternatively, placing sediments over a large area in thin layers or hydraulically dredged slurries in geotextile tubes.	Required component for removal actions; all process options are considered effective and implementable for Pearl Harbor Sediment site.
		Mechanical	Using mechanical means (e.g., belt presses, filtration, heat/forced air systems) to enhance and accelerate the dewatering process.	
		Additives	Mixing additives (e.g., lime, cement, fly ash, kiln dust) into sediment to decrease free porewater content, solidify sediment and shorten dewatering time.	
	Transportation	Mechanical	Transport of dredged sediment material using floating barges and trucks.	Required component for removal actions; all process options are considered effective and implementable for Pearl Harbor Sediment site.
		Hydraulic	Transport of dredged material with higher water content in a slurry form; requires pumping and pipeline system.	
	Munition Response	Screening and Removal of Munition	Screening and removal of any munition found in dredged material from areas of high potential for encountering UXO.	Potentially required component for removal actions in areas identified as having a high potential for encountering UXO.

Table 2-13: Technologies Retained for Development of Remedial Alternatives for Pearl Harbor Sediment

GRA	Technology Type	Process Option	Description	Screening Comments
Ex-situ Treatment	Physical Treatment	Sediment Washing	Two-step process that include physical separation into different grain-size fractions, followed by chemical washing. Requires dewatering and treatment.	Not retained due to the potentially significant increase of sediment volume to be disposed of off site. In addition, the sand content of sediments in the six DUs is not high enough to justify the effort and expense for implementation.
Disposal	Onsite or Offsite Disposal	Confined Aquatic Disposal (CAD)	Placement of and capping of contaminated sediment in horizontal layers in suitable underwater location near site.	The overall space (volume) capacity for CAD is limited. However, adequate capacity may be available to contain substantial portion of the contaminated dredged sediment for those alternatives requiring the least amount of dredging. However, for most alternatives, CAD will not be adequate for project-wide application, but could serve to contain a portion of the contaminated sediment. Substantial implementability logistics issues need to be addressed with CAD. Also, constraints with long-term ICs (e.g., conflict if located within established dredging areas) and multiple agency approvals to authorize the site are a concern.
		Confined Disposal Facility (CDF)	Nearshore or upland confined disposal area.	Not applicable to Pearl Harbor site-wide application because of limited locations (and capacity) without other current uses. May be applicable for smaller-scale location-specific application.
	Offsite Disposal	Existing Subtitle C Landfill	Disposal in a landfill permitted to receive RCRA or TSCA waste – not available on-island.	Applies specifically to sediment that is characterized as hazardous or dangerous in accordance with federal or state regulations. This condition is not expected to occur on a large scale and more likely will be limited to localized hotspot removal areas, if triggered at all.
		Existing Subtitle D Landfill	Disposal in an existing, on-island Subtitle D landfill.	Very limited capacity; preferred option for offsite landfill disposal given the on-island availability.
	Open-water Disposal	SOODMDS	Disposal in the SOODMDS.	Restricted applicability due to the CERCLA “Off Site Rule.” However, although dredged material may be too high in CERCLA hazardous substances for ocean disposal, some material may still be suitable for ocean disposal.

Note: Representative site-wide process options included in the development of the remedial alternatives and cost estimates for this FS. Other process options may have location-specific applicability; but not site-wide applicability.
O&M operations and maintenance
TSCA Toxic Substances Control Act
UXO unexploded ordnance

Table 2-14: Summary of Remedial Alternative Screening Results for the Six Remediation DUs

DU	Screened Remedial Alternative
SE-1 (Southeast Loch)	1: No Action
	2: MNR with Continued Maintenance Dredging (achieve PRGs in 30 years)
	3: Dredging
	4: Extensive Dredging
	5: ENR
	6: Capping and Partial Dredging
	7: Focused Dredging with ENR
	8: Focused Capping and Partial Dredging with ENR
	9: Focused Dredging with MNR (achieve PRGs in 10 years)
	10: Focused Capping and Partial Dredging with ENR and MNR (achieve PRGs in 10 years)
	11: Focused Dredging with MNR (achieve PRGs in 20 years)
	12: Focused Capping and Partial Dredging with ENR, AC, and MNR (achieve PRGs in 20 years)
	13: Focused Dredging with ENR, AC, and MNR (achieve PRGs in 20 years)
N-2 (Oscar 1 and 2 Piers Shoreline)	1: No Action
	2: MNR with Continued Maintenance Dredging (achieve PRGs in 20 years)
	3: Dredging
	4: ENR
	5: Capping and Partial Dredging
	6: Focused Dredging with ENR
	7: Focused Capping and Partial Dredging with ENR
	8: Focused Dredging with MNR (achieve PRGs in 10 years)
	9: Focused Capping and Partial Dredging with ENR and MNR (achieve PRGs in 10 years)
	10: ENR with MNR (achieve PRGs in 10 years)
N-3 (Off Ford Island Landfill and Camel Refurbishing Area)	1: No Action
	2: MNR (achieve PRGs in 10 years)
	3: Dredging
	4: ENR
	5: Capping
N-4 (Bishop Point)	1: No Action
	2: MNR with Continued Maintenance Dredging (achieve PRGs in 30 Years)
	3: Dredging
	4: ENR
	5: Capping and Partial Dredging
	6: Focused Dredging with MNR (achieve PRGs in 10 years)
E-2 (Off Waiau Power Plant)	1: No Action
	2: MNR (achieve PRGs in 30 years)
	3: Dredging
	4: ENR
	5: Capping
	6: Focused Dredging with ENR
	7: Focused Capping with ENR
	8: Focused Dredging with MNR (achieve PRGs in 10 years)
	9: Focused Capping with ENR and MNR (achieve PRGs in 10 years)
E-3 (Aiea Bay)	1: No Action
	2: MNR (achieve PRGs in 10 years)
	3: Dredging
	4: Extensive Dredging
	5: ENR
	6: Capping

Note: Shaded cell indicates alternative retained for Detailed and Comparative Analysis.

2.9.1 Source Controls

In accordance with EPA (2005) guidance and Navy policy (DON 2002), remedial actions should not commence until appropriate source control measures have been implemented and their effectiveness verified. Source control is assumed to be an integral part of all remedial actions (except the No Action Alternative) to ensure that ongoing sources and pathways such as contaminated upland sites, storm water, and industrial discharges that may cause recontamination after cleanup have been addressed. Because it may be difficult or impossible to fully control all sources of ongoing contamination, the potential for recontamination following remediation was considered in the ranking of the remedial alternatives. Alternatives that would be relatively resilient to recontamination and maintain long-term effectiveness are rated higher than alternatives that would provide little or no resilience.

Source control is an iterative process. Information and data acquired during long-term monitoring should be used to re-evaluate and optimize the performance of source control measures. Data representing contaminant sources and transport pathways in one portion of the watershed may influence source control investigations and actions in other portions of the watershed. Additional source control investigations, upland site assessment and cleanup, inspections, source tracing, sampling, and monitoring should be conducted regularly to address each potential point and non-point source of sediment contamination.

In order to prevent recontamination following remedy implementation, source control should be complete before in-water sediment remediation begins. Specific source controls will vary depending on specific site conditions and will be determined during remedial design. The following are the most likely potential pathways for the recontamination of Pearl Harbor sediments:

- Point source water and suspended solids discharge from upland impervious areas via catch basins and outfalls, including runoff from specific contaminant sources and industrial activities
- Sediment movement from maintenance dredging that resuspends sediments in contaminated areas

Each pathway is discussed in the following subsections along with potential source control measures that could be implemented, followed by a discussion of uncertainty factors that could affect the recontamination potential for Pearl Harbor sediments.

2.9.1.1 STORM WATER OUTFALL DISCHARGES

Surface water discharges from public or private storm drain systems, combined sewer overflows, or emergency overflows are potential pathways for release of contaminants to Pearl Harbor. The 2012 FS sampling results indicate that COC concentrations in surface sediments near many of the storm drain outfalls exceed the PRGs, suggesting that the storm drain outfalls represent potential ongoing sources of sediment contamination (DON 2015). In many cases, analytical results from sediment collected from sediment traps located at outfalls within Pearl Harbor can be linked to specific sources of contaminants released to the storm drains. Examples include elevated COC concentrations in harbor sediments near outfalls that discharge runoff from the Waiau Power Plant (PCBs), from JBPHH (antimony, a major component of fire retardants), and from the Dry Dock areas (multiple chemicals used in the Shipyard). In most cases, receiving sediment trap samples collected near outfalls contained concentrations of one or more COCs that exceeded the PRGs. In many cases, the COC profile reported for the sediment trap samples matched the COC profile associated with specific upland contaminant sources in the local watershed. Outfall discharge is typically event-based (e.g., high runoff during periods of rain), resulting in large water and sediment loads over short periods. Surface water runoff from impervious areas often contains chemicals associated with industrial products, other concentrated waste materials, and high levels of suspended fine-grained particles (which typically contain higher COC concentrations than coarse sediments). First-flush events caused by heavy storms following long dry periods typically discharge high loads of contaminants associated with street dust, oil, and other residuals that accumulate during dry periods.

Best management practices (BMPs) for controlling these sources include treatment methods such as gravity separation and removal, biofiltration, hydrodynamic separation, and simple filtration, which could significantly decrease the probability of recontamination by removing sediments and associated contaminants prior to discharge to the harbor. Catch basin or inline storm drain sediment sampling data would be useful in the remedial design phase to confirm the loading estimates and identify the type and extent of BMPs required to control these sources. In lieu of filtration or treatment, enhanced and more frequent maintenance for the removal of gravity-accumulated sediment in catch basins may be sufficient to prevent or limit discharge of contaminated sediments to the harbor. Frequent catch-basin cleaning can significantly decrease sediment loads discharged during periods of high flow. The Navy is currently preparing plans to remove sediments from the storm drain system in the Shipyard area (DON 2012).

2.9.1.2 Maintenance Dredging

Redistribution of contaminated sediment remaining in place after remediation is a potential pathway of concern for recontamination. As indicated by subsurface COC concentrations, sediment contamination may be exposed during maintenance dredging within DUs SE-1, N-2, and N-4. Unless the remedies are implemented to include partial dredging to gain sufficient clearance for future maintenance dredging activities, or the maintenance dredging elevation is changed, subsurface contamination may continue to potentially be re-exposed by maintenance dredging activities. BMPs (e.g., turbidity curtains) should be used during maintenance dredging to limit or prevent post-remediation recontamination.

2.9.1.3 Uncertainty

The success of any remedial action may be limited unless appropriate source control measures are implemented. As noted above, a key premise of EPA’s (2005) sediment remediation guidance and Navy policy (DON 2002) is that active remediation should not be performed until after sources have been controlled to the extent necessary to prevent post-remediation recontamination. The analysis conducted as part of the FS was consistent with these principles. However, additional remedial-design-level evaluation will be considered to further evaluate the potential for recontamination (and natural recovery) of surface sediments after remedial actions have been completed.

2.9.2 Coordination with the Maintenance Dredging Program

The Pearl Harbor maintenance dredging program will most likely have a large impact on site conditions, site resources, and costs for environmental remediation. Therefore, methods and procedures for coordinating environmental dredging and other remedial construction activities with the maintenance dredging program should be developed during the remedial design phase of the project.

The remediation footprints in DUs SE-1, N-2, and N-4 overlap with the maintenance dredging areas; therefore, remedial construction for these DUs will be scheduled around the maintenance dredging activities (Figure 1-2). The most recent maintenance dredging was conducted from 2002–2011. The approximate planned dredging cycle is 10–14 years, depending on location. In some cases, remediation could take advantage of the maintenance dredging activities, e.g., by performing environmental dredging in conjunction with maintenance dredging, or by performing placement activities (e.g., capping or ENR material placement) soon after maintenance dredging activities are completed to reduce the risk due to exposure of subsurface sediment. In addition, repair activities (e.g., placing additional ENR material) could be scheduled to follow maintenance dredging activities in each area of concern.

Finally, maintenance dredging of sediments with relatively low COC concentrations could serve as a source of clean material to address dredge residual or for ENR implementation. This approach could result in substantial cost savings for both the maintenance dredging and environmental remediation programs.

2.9.3 Summary of Retained Remedial Alternatives for DU SE-1 (Southeast Loch)

Eight of the 13 remedial alternatives developed for DU SE-1 were retained for detailed and comparative analysis:

- Alternative 1: No Action
- Alternative 2: MNR with Continued Maintenance Dredging (achieve PRGs in 30 years)
- Alternative 3: Dredging
- Alternative 5: ENR
- Alternative 8: Focused Capping and Partial Dredging with ENR
- Alternative 10: Focused Capping and Partial Dredging with ENR and MNR (achieve PRGs in 10 years)
- Alternative 12: Focused Capping and Partial Dredging with ENR, AC, and MNR (achieve PRGs in 20 years)
- Alternative 13: Focused Dredging with ENR, AC, and MNR (achieve PRGs in 20 years)

These alternatives are summarized in Table 2-15 and described below.

Table 2-15: DU SE-1 (Southeast Loch) Summary of Retained Remedial Alternatives

Retained Remedial Alternative	Summary
1: No Action	• Retained as baseline for comparison to other alternatives per CERCLA requirement. • RAOs may potentially be achieved within 30 years based on natural recovery model. • Does not include ICs, monitoring, or contingency actions to achieve RAOs. • Total cost is $0.
2: MNR with Continued Maintenance Dredging (achieve PRGs in 30 years)	• Monitoring ongoing natural recovery progress to reduce COC concentrations (227 acres). • RAOs may potentially be achieved within 30 years based on natural recovery model. • Total cost is $10 million (M) ($10M operational cost, $0 operation and maintenance [O&M]).

Table 2-15: DU SE-1 (Southeast Loch) Summary of Retained Remedial Alternatives

Retained Remedial Alternative	Summary
3: Dredging	• Remove 1.2 million yd^3 of surface sediment over 149 acres; placement of thin layer of clean material (6-inch) to address dredge residual contamination; in-situ treatment of under-pier sediments with AC amendment (13 acres). • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill, depending on the COC concentrations. • All RAOs would be achieved following construction (approximately 3 years). • Total cost is $470M ($467M capital; $3M O&M). Cost may by significantly higher due to the potential for encountering munitions during dredging.
5: ENR	• Placement of thin layer (6-inch) of clean material to accelerate natural recovery process (149 acres); in-situ treatment of under-pier sediments with AC amendment (13 acres). • RAOs would be achieved in 10 years. • Total cost is $76M ($68M capital; $8M O&M).
8: Focused Capping and Partial Dredging with ENR	• Partial dredging for cap clearance (23 acres; 320,000 yd^3); placement of thin layer of clean material (6 inches) to address dredge residual contamination; placement of 3-foot cap of clean material in areas with higher contamination (35 acres); placement of thin layer of clean material in areas of moderate contamination areas (91 acres); in-situ treatment of under-pier sediments with AC amendment (13 acres). • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill. • RAOs achieved immediately following construction (approximately 1 year). • Total cost $210M ($202M capital; $8M O&M).
10: Focused Capping and Partial Dredging with ENR and MNR (achieve PRGs in 10 years)	• Partial dredging for cap clearance (16 acres; 220,000 yd^3); placement of thin layer of clean material (6 inches) to address dredge residual contamination; placement of 3-foot cap of clean material in areas with higher contamination (21 acres); placement of thin layer of clean material in areas of moderate contamination areas (42 acres); in-situ treatment of under-pier sediments with AC amendment (13 acres); monitoring in areas of lower contamination (70 acres). • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill. • RAOs achieved in approximately 10 years following construction. • Total cost $140M ($133M capital; $7M O&M).
12: Focused Capping and Partial Dredging with ENR, AC, and MNR (achieve PRGs in 20 years)	• Partial dredging for cap clearance (3 acres; 28,000 yd^3); placement of thin layer of clean material (6 inches) to address dredge residual contamination; placement of 3-foot cap of clean material in areas with higher contamination (2 acres); placement of thin layer of clean material in areas of moderate contamination areas (32 acres); in-situ treatment with AC amendment in overwater areas (34 acres) and under-pier sediments (8 acres); monitoring in areas of lower contamination (117 acres). • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill. • RAOs achieved in approximately 20 years following construction. • Total cost $49M ($42M capital; $7M O&M).
13: Focused Dredging with ENR, AC, and MNR (achieve PRGs in 20 years)	• Removal of sediments with high COC concentrations (2 acres; 17,000 yd^3); placement of thin layer of clean material (6-inch) to address dredge residual contamination; placement of a thin layer of clean material over sediments with moderate concentrations to enhance natural recovery (12.6 acres); in-situ treatment with AC amendment in overwater areas (11 acres) and under-pier sediments (8 acres); monitoring of natural recovery progress for sediments with low COC concentrations (139 acres). • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill, depending on the COC concentrations. • RAOs achieved in approximately 20 years following construction. • Total cost $31.4M ($24.2M capital; $7.2M O&M). [a]

Note: Shaded cell indicates the preferred remedial alternative selected for the DU.
[a] The estimated cost of the preferred remedy was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

Alternative 1: No Action. The No Action alternative is required by CERCLA to establish a baseline for comparison to other remedial alternatives. The No Action alternative is based on the assumption that site conditions will be left in their current state and no ICs, monitoring, or other actions will be implemented to reduce risk or ensure achievement of the RAOs. RAOs 1 and 2 may not be achieved under the No Action alternative; however, based on natural recovery estimates, RAOs 1 and 2 could be potentially achieved in approximately 30 years and 10 years, respectively. The total cost of this alternative is $0.

Alternative 2: MNR with Continued Maintenance Dredging (30 Years). Alternative 2 relies on natural recovery processes to reduce surface sediment COC concentrations and to achieve the PRGs and reduce the human health and ecological risks over time. MNR establishes goals, a period to achieve those goals, a monitoring program to track success, and a decision framework for adaptive management. The cleanup goals are the PRGs, which will be achieved when the RAL_0 criteria are met, resulting in DU-wide SWACs at or below the PRGs. Based on baseline conditions and model predictions, the period required to achieve the PRGs by natural recovery alone is approximately 30 years. Monitoring events would occur in years 2, 5, and 10, and at 5-year intervals until the end of the 30-year period. Periodic maintenance dredging activities during the recovery period could potentially expose subsurface sediment with a higher level of contamination; however, they may also reduce the mass of contamination and potentially the exposure levels during the recovery period. After 30 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary. For the cost estimates, it is assumed that 5 percent of the footprint would require contingency actions. MNR would apply to 227 acres of sediment with surface sediment COC concentrations exceeding the PRGs. No dredging volume is associated with this alternative, although contingency actions could include removing contaminated sediment, or pre-dredging as required to accommodate a cap or ENR layer. The total cost is estimated at $10 million net present value (NPV) and includes costs for site-wide remedial goal monitoring and costs for sampling NAR DUs as part of the Navy-EPA agreement (DON 2015, Appendix F).

Alternative 2 would include ICs to prevent or limit exposure of human receptors to acceptable levels by restricting human access to the contaminated sediment and limiting the potential for human consumption of fish, shellfish, and other aquatic organisms that may bioaccumulate COCs in Southeast Loch. The Navy owns and controls access to the harbor and shoreline surrounding Southeast Loch; therefore, land use controls (LUCs), access restrictions, and security measures are already in place. ICs are also necessary to prevent exposure of buried sediment contamination for a remedial alternative that leaves subsurface sediment contamination in place. Public advisories regarding fish and shellfish consumption are currently posted along the shoreline of Pearl Harbor, including Southeast Loch. This alternative would not implement ICs to address pathways for exposure of ecological receptors. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately. Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 30 years. RAO 2 would be achieved in approximately 10 years. RAO 3 is not applicable for DU SE-1 because of the lack of shallow water areas for waterbirds to access sediment or consume bottomfish.

Alternative 3: Dredging. Alternative 3 would dredge sediments in areas with surface sediment COC concentrations exceeding the RAL_0 criteria (420 µg/kg for total PCBs and 1.3 mg/kg for mercury). Dredging would extend down to the depth of RAL_0 exceedances. In areas with structural or access limitations (i.e., under-pier areas), Alternative 3 would use in-situ treatment to remediate under-pier areas with surface sediment COC concentrations exceeding the RAL_0 criteria. Dredging would be performed over 149 acres, and under-pier in-situ treatment would be performed over

13 acres. The average thickness of sediments that would be removed is 3.3 feet, yielding a total dredge volume of approximately 1,200,000 yd^3. The total sand placement volume for managing dredge residuals is approximately 120,000 yd^3. Construction is expected to require 3 years. The total cost is estimated at $470 million NPV and includes costs for site-wide remedial goal monitoring and costs for sampling and analysis to monitor the NAR DUs as part of the Navy-EPA agreement (DON 2015, Appendix F). Dredging and disposal of contaminated sediment would be performed and ICs would continue to be maintained and modified as necessary. Construction, performance, and remedial goal monitoring would be conducted to ensure that the remedy performs as predicted.

This alternative would achieve RAO 1 and RAO 2 immediately after remedial construction is complete. Alternative 3 includes ICs, monitoring, and adaptive management to ensure the achievement of RAOs.

Alternative 5: ENR. Alternative 5 would remediate DU SE-1 sediments through natural physical processes augmented with a thin layer of clean material to increase the rate of natural recovery:

- ENR would be implemented in areas with surface COC sediment concentrations exceeding the RAL_0 criteria (420 µg/kg for total PCBs and 1.3 mg/kg for mercury).
- In-situ treatment with AC amendment would be implemented to remediate surface sediments with COC concentrations exceeding the RAL_0 criteria over a 13-acre area where existing structures (e.g., piers) limit access for remedial construction.

Approximately 2.5 feet of sediment could require partial dredging prior to ENR material placement within navigation areas to gain clearance as needed to avoid future disturbance of the ENR layer by maintenance dredging activities. However, costs for this partial dredging are not included in the cost estimate based on the assumption that partial dredging would be accomplished under the maintenance dredging program.

ENR would be implemented over 149 acres and approximately 13 acres of under-pier areas would be remediated by in-situ treatment with AC amendment. The total placement volume of ENR capping material is approximately 210,000 yd^3. Construction is expected to require 1 year. The total cost is estimated at $76 million NPV and includes costs for site-wide remedial goal monitoring and costs for sampling NAR DUs as part of the Navy-EPA agreement (DON 2015, Appendix F).

An extensive performance monitoring program would be implemented to confirm that the recovery processes proceed at rates sufficient to meet the final RAOs within a reasonable period. ICs would be implemented to ensure that buried contamination remains in place. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately. Natural recovery estimates indicate that RAO 1 would be achieved through reduction in SWACs in approximately 10 years. RAO 2 would be achieved immediately after remedial construction is complete. Although Alternative 5 is predicted to achieve the RAOs in 10 years, it may not address localized hotspots with relatively high COC concentrations in surface sediment.

Alternative 8: Focused Capping and Partial Dredging with ENR. Alternative 8 would isolate and immobilize COCs in DU SE-1 by placing conventional sand cap materials over the areas with the highest surface sediment COC concentrations, and ENR materials over areas with lower surface sediment COC concentrations:

- Capping would be implemented in all areas with surface sediment COC concentrations exceeding 2 × RAL_0 criteria (840 µg/kg for total PCBs and 2.6 mg/kg for mercury).
- ENR would be implemented in all areas with surface sediment COC concentrations between the RAL_0 criteria and 2 × the RAL_0 criteria (420–840 µg/kg for total PCBs and 1.3-2.6 mg/kg for mercury).
- In areas with structural or access limitations (e.g., under-pier areas), AC amendment would be used to remediate areas with surface sediment COC concentrations exceeding the RAL_0 criteria.

Approximately 5 feet of sediment would require partial dredging prior to cap material placement within navigation areas. 2.5 feet is assumed to be removed during environmental remediation, and another 2.5 feet is assumed to be removed by the maintenance dredging program. Locations where dredging to a depth of 5 feet would remove all sediment with concentrations exceeding the RAL_0 criteria would be fully dredged as opposed to capped, because capping would no longer be necessary. For this reason, Alternative 8 includes a significant amount of dredging. Preliminary estimates indicate that 60 percent of the DU SE-1 remedial action footprint would be fully dredged as opposed to partially dredged and capped. Similar to Alternative 5, the cost estimate assumes that partial dredging prior to placement is unnecessary for ENR areas; however, this assumption would need to be re-evaluated during the design phase if this alternative is selected.

Dredging would be implemented over 23 acres, capping over 35 acres, and ENR over 91 acres, with 13 acres of in-situ treatment with AC amendment under piers. The total surface area for active remediation is 162 acres. The total volume of sediment to be removed in preparation for capping is approximately 320,000 yd^3. The total placement volume of cap material is approximately 350,000 yd^3. Construction is expected to require 1 year. The total cost is estimated at $210 million NPV and includes costs for site-wide remedial goal monitoring and costs for sampling NAR DUs as part of the Navy-EPA agreement (DON 2015, Appendix F).

ICs would continue to be maintained and modified as needed to ensure that buried contamination remains in place. Long-term monitoring would be performed to ensure that the caps are functioning as anticipated and maintenance and repairs would be made as needed. Active remediation would reduce risks in the short term to achieve RAOs 1 and 2 immediately after remedial construction is completed.

Alternative 10: Focused Capping and Partial Dredging with ENR and MNR (10 years). Alternative 10 would isolate and immobilize COCs in DU SE-1 by placing conventional sand caps over areas with the highest surface sediment COC concentrations, with ENR for areas with moderate surface sediment COC concentrations, and MNR for areas with the lowest surface sediment COC concentrations:

- Capping would be implemented in all areas with surface sediment COC concentrations exceeding 2 × the RAL_{10} criteria (1,500 µg/kg for total PCBs and 4.2 mg/kg for mercury).
- ENR would be implemented in all areas with surface sediment COC concentrations between the RAL_{10} criteria and 2 × the RAL_{10} criteria (740–1,500 µg/kg for total PCBs and 2.1–4.2 mg/kg for mercury).
- MNR would be implemented in areas with concentrations between the RAL_0 criteria and the RAL_{10} criteria (420–740 µg/kg for total PCBs and 1.3–2.1 mg/kg for mercury).

- In areas with structural or access limitations (under-pier areas), in-situ treatment with AC amendment would be used to remediate areas with surface sediment COC concentrations exceeding the RAL_{10} criteria, with MNR for areas with concentrations between the RAL_0 and RAL_{10} criteria.

Partial dredging and full dredging would be implemented in potential capping areas as described for Alternative 8 above. Similar to Alternative 5, the cost estimate for Alternative 10 assumes that partial dredging prior to placement is unnecessary for ENR areas; however, this assumption would need to be re-evaluated during the design phase if this alternative is selected. MNR would be implemented over a 10-year period; it would apply to areas with lower COC concentrations. Dredging would be implemented over 16 acres, capping over 21 acres, ENR over 42 acres, and MNR over 70 acres, with 13 acres of in-situ treatment with AC amendment under piers. The total surface area for active remediation is 92 acres. The total volume of sediment to be removed as preparation for capping is approximately 220,000 yd^3. The total volume of cap material is approximately 210,000 yd^3. Construction is expected to require 1 year. The total cost is estimated at $140 million NPV and includes costs for site-wide remedial goal monitoring and costs for sampling NAR DUs as part of the Navy-EPA agreement (DON 2015, Appendix F). After 20 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary.

ICs would continue to be maintained and modified as needed to ensure that buried contamination will remain in place. Long-term monitoring would be performed to ensure that the caps are functioning as anticipated and maintenance and repairs would be performed as needed. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately after remedial construction is completed. Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 10 years. RAO 2 would be achieved upon completion of construction.

Alternative 12: Focused Capping and Partial Dredging with ENR, AC, and MNR (20 years). Like Alternative 10, Alternative 12 would implement capping, ENR with in-situ treatment AC amendment, and MNR in locations with the highest concentrations, moderate concentrations, and the lowest concentrations respectively. However, Alternative 12 has higher action levels to achieve PRGs in 20 years:

- Capping would be implemented in all areas with surface sediment COC concentrations exceeding 2 × the RAL_{20} criteria (2,600 µg/kg for total PCBs and 8.0 mg/kg for mercury).
- ENR would be implemented in all areas with surface sediment COC concentrations between the RAL_{20} criteria and 2 × the RAL_{20} criteria (1,300–2,600 µg/kg for total PCBs and 4.0–8.0 mg/kg for mercury). In-situ treatment with AC amendment would also be implemented in ENR areas where surface sediment PCB concentrations are greater than RAL_{10} criterion for PCBs (740 µg/kg).
- MNR would be implemented in areas with concentrations between the RAL_0 and RAL_{20} criteria (420–1,300 µg/kg for total PCBs and 1.3–4.0 mg/kg for mercury). In-situ treatment with AC amendment would also be implemented in MNR areas where surface sediment PCBs concentrations are greater than RAL_{10} criterion for PCBs (740 µg/kg).
- In areas with structural or access limitations (under-pier areas), AC amendment would be used to treat areas with surface sediment COC concentrations exceeding the RAL_{20} criteria, with MNR for areas with concentrations between the RAL_0 and RAL_{20} criteria.

Partial dredging and full dredging would be implemented in potential capping areas as described for Alternative 8 above. Similar to Alternative 5, the cost estimate for Alternative 12 assumes that partial dredging prior to placement is unnecessary for ENR areas; however, this assumption would need to be re-evaluated during the design phase if this alternative is selected. MNR would be implemented over a 20-year period; it would apply to areas with lower concentrations. Dredging would be implemented over 3 acres, capping over 2 acres, ENR over 32 acres, and MNR over 117 acres, with 8 acres of in-situ treatment application under piers. The total surface area for active remediation is 45 acres. The total volume of sediment to be removed as preparation for capping is approximately 28,000 yd^3. The total placement volume of cap material is approximately 88,000 yd^3. Construction is expected to require less than 1 year. The total cost is estimated at $49 million NPV and includes costs for site-wide remedial goal monitoring and costs for sampling NAR DUs as part of the Navy-EPA agreement (DON 2015, Appendix F). After 20 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary.

ICs would continue to be maintained and modified as needed to ensure that buried contamination will remain in place. Long-term monitoring would be performed to ensure that the caps are functioning as anticipated and maintenance and repairs would be performed as needed. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved upon completion of construction. Natural recovery estimates indicate that RAO 1 would be achieved through reduction in SWACs in approximately 20 years. RAO 2 would be achieved when construction is completed.

Alternative 13: Focused Dredging with ENR, AC, and MNR (20 Years). Alternative 13 would implement focused dredging, ENR, with in-situ treatment with an AC amendment, and MNR in locations with the highest concentrations, moderate concentrations, and the lowest concentrations, respectively, to achieve PRGs in 20 years:

- Dredging would be implemented in all areas with surface sediment COC concentrations exceeding 2 × the RAL_{20} criteria (2,600 µg/kg for total PCBs and 8.0 mg/kg for mercury).
- ENR would be implemented in all areas with surface sediment COC concentrations between the RAL_{20} criteria and 2 × the RAL_{20} criteria (1,300–2,000 µg/kg for total PCBs and 4.0–8.0 mg/kg for mercury). In-situ treatment with AC amendment would also be implemented in ENR areas where surface sediment PCBs concentrations are greater than RAL_{10} criterion for PCBs (740 µg/kg).
- MNR would be implemented in areas with concentrations between the RAL_0 and RAL_{20} criteria (420–1,300 µg/kg for total PCBs and 1.3–4.0 mg/kg for mercury). In-situ treatment with AC amendment would also be implemented in MNR areas where surface sediment PCBs concentrations are greater than RAL_{10} criterion for PCBs (740 µg/kg).
- In areas with structural or access limitations (under-pier areas), AC amendment would be used to remediate areas with surface sediment COC concentrations exceeding the RAL_{20} criteria, with MNR for areas with concentrations between the RAL_0 and RAL_{20} criteria.

A 2-acre area of sediments with relatively high COC concentrations would be dredged, while 12.6 acres would be treated with ENR, approximately 139 acres would be remediated with MNR, and a 8-acre area under the piers and a 11-acre overwater area would be treated in-situ with AC. Similar to Alternative 5, the cost estimate for Alternative 13 assumes that partial dredging prior to placement is unnecessary for ENR areas; however, this assumption would need to be re-evaluated during the design phase if this alternative is selected. The total area designated for active remediation is approximately 34 acres. MNR would continue for approximately 20 years as required to meet the remedial objectives for sediments with relatively low COC concentrations. The total volume of sediment to be removed by dredging is approximately 17,000 yd^3, and the total volume of clean material required for ENR and to address dredge residual is approximately 17,000 yd^3. The remedial construction phase is expected to require less than 1 year. The total cost is estimated at $31.4 million NPV, including costs for site-wide remedial goal monitoring and costs for sampling and analysis of sediments in the NAR DUs as part of the Navy-EPA agreement for long-term monitoring (DON 2015, Appendix F).

ICs would continue to be maintained and modified as needed to ensure that buried contamination will remain in place. Long-term monitoring would be performed to ensure that the remedy as functioning as anticipated and maintenance and repairs would be performed as needed. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved upon completion of construction. Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 20 years. RAO 2 would be achieved when remedial construction is completed.

2.9.4 Summary of Retained Remedial Alternatives for DU N-2 (Oscar 1 and 2 Piers Shoreline)

Five of the 10 remedial alternatives developed for DU N-2 were retained for detailed and comparative analysis:

- Alternative 1: No Action
- Alternative 2: MNR with Continued Maintenance Dredging (achieve PRGs in 20 years)
- Alternative 3: Dredging
- Alternative 8: Focused Dredging with MNR (achieve PRGs in 10 years)
- Alternative 10: ENR and MNR (achieve PRGs in 10 years)

These alternatives are summarized in Table 2-16 and described below.

Table 2-16: DU N-2 (Oscar 1 and 2 Piers Shoreline) Summary of Retained Remedial Alternatives

Retained Remedial Alternative	Summary
1: No Action	• Retained as baseline for comparison to other alternatives per CERCLA requirement. • RAOs may potentially be achieved within 20 years based on natural recovery model. • Does not include ICs, monitoring, or contingency actions to achieve RAOs. • Total cost is $0.
2: MNR with Continued Maintenance Dredging (achieve PRGs in 20 years)	• Monitoring ongoing natural recovery progress to reduce COC concentrations (24 acres). • RAOs may potentially be achieved within 20 years based on natural recovery model. • Total cost is $10 million (M) ($0 operational, $10M O&M).
3: Dredging	• Remove 150,000 yd^3 of surface sediment over 16 acres; placement of thin layer of clean material to address residual contamination; in-situ treatment of under-pier sediments with AC (0.1 acre). • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill. • All RAOs would be achieved following construction (approximately 5 months). • Total cost is $60M ($59.1M capital; $0.1M O&M).

Table 2-16: DU N-2 (Oscar 1 and 2 Piers Shoreline) Summary of Retained Remedial Alternatives

Retained Remedial Alternative	Summary
8: Focused Dredging with MNR (achieve PRGs in 10 years)	• Remove 29,000 yd^3 of surface sediment over 3 acres; placement of thin layer of clean material to address residual contamination; in-situ treatment of under-pier sediments with AC (0.7 acre); monitoring in areas of lower contamination (12 acres). • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill, depending on the COC concentrations. • RAOs achieved in approximately 20 years following construction. • Total cost $13M ($12M capital; $1M O&M).
10: ENR and MNR (achieve PRGs in 10 years)	• Placement of thin layer of clean material in areas of moderate contamination areas to enhance natural recovery (1.6 acres); in-situ treatment with AC for under-pier sediments (0.7 acre); monitoring natural recovery progress in areas of lower contamination (14.2 acres). • RAOs achieved in approximately 10 years following construction. • Total cost $1.9M ($1.3M capital; $0.6M O&M). [a]

Note: Shaded cell indicates the preferred remedial alternative selected for the DU.
[a] The estimated cost of the preferred remedy was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

Alternative 1: No Action. The No Action alternative is included in the screening evaluation as a baseline for comparison with the other remedial action alternatives in accordance with CERCLA. The alternative would require natural recovery to achieve RAOs over time. Based on natural recovery rate estimates, RAO 1 would be achieved through reduction in SWACs in approximately 20 years, and RAO 2 would be achieved immediately. Alternative 1 includes no ICs, monitoring, or adaptive management to reduce risk or ensure the achievement of RAOs. The total cost of this alternative is $0.

Alternative 2: MNR with Continued Maintenance Dredging (achieve PRGs in 20 Years). Alternative 2 would rely on natural recovery processes to reduce surface sediment COC concentrations and associated human health and ecological risks to achieve PRGs over time. Based on baseline conditions and model predictions, the period required to achieve the PRGs by natural recovery is approximately 20 years. Monitoring events are assumed to occur in years 2, 5, and 10, and every 5 years afterward for 20 years. After 20 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary. For the cost estimates, it is assumed that 5 percent of the footprint would require dredging as a contingency action.

MNR would apply to 24 acres of sediment with surface sediment COC concentrations exceeding the PRGs for all COCs. No dredging volume is associated with this alternative, although contingency actions could include dredging, as well as capping or ENR. The total cost is estimated at $1 million NPV and does not include site-wide remedial goal monitoring (included in the cost estimate for DU SE-1).

During the recovery period, Alternative 2 would rely on ICs to prevent or limit exposure of human receptors to acceptable levels by restricting human access to the contaminated sediment, and limiting the potential for human consumption of fish, shellfish, and other aquatic organisms that may bioaccumulate the COCs. The Navy owns and controls access to the navigation channel, Oscar 1 and 2 Piers, and all other shoreline areas adjacent to this DU; therefore, LUCs, access restrictions, and security measures are already in place. Public advisories regarding fish and shellfish consumption are posted along the shoreline. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately. Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 20 years. RAO 2 would be achieved immediately.

Alternative 3: Dredging. Alternative 3 would dredge sediments in areas with surface sediment COC concentrations exceeding the RAL_0 criteria (380 µg/kg for total PCBs and 1.4 mg/kg for mercury) to 4 feet in depth (plus overdredge). Approximately 16 acres of sediments would be dredged and 0.7 acre of under-pier sediments would be designated for in-situ treatment. Approximately 50 percent of the dredge footprint is assumed to require thin-layer clean material placement to manage dredge residuals. The total dredging volume is 150,000 yd^3, and the total thin-layer material volume is 11,000 yd^3. Construction is estimated to require 5 months. The total cost is estimated at $60 million NPV. The alternative would achieve RAOs 1 and 2 immediately after construction. Alternative 3 includes ICs, monitoring, and adaptive management to ensure the achievement of RAOs.

Alternative 8: Focused Dredging with MNR (10 Years). Alternative 8 would combine MNR with focused dredging and ICs:

- Dredging would remove sediment in portions of DU N-2 where surface sediment COC concentrations exceed the RAL_{10} criteria (670 µg/kg for total PCBs and 2.3 mg/kg for mercury), and would extend down to the depths required to remove subsurface sediments with COC concentrations exceeding the RAL_0 criteria.
- MNR would be used to address portions of DU N-2 with surface sediment COC concentrations exceeding the RAL_0 criteria (380 µg/kg for total PCBs and 1.4 mg/kg mercury) but less than the RAL_{10} criteria.
- In-situ treatment with AC amendment would be used remediate areas with structural or access limitations that have surface sediment COC concentrations exceeding the RAL_{10} criteria.

Dredging would be required for approximately 3 acres, MNR for 12 acres, and under-pier AC amendment treatment for 0.7 acre. The total removal volume is 29,000 yd^3, and the total material placement volume is 3,600 yd^3. Construction is estimated to take 1 month. The total costs are estimated at $13 million NPV. After 10 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary.

Like Alternative 2, the goal of MNR is to achieve the PRGs, but under this alternative the PRGs would be achieved in 10 years. ICs would continue to be maintained and modified as needed to ensure that buried contamination will remain in place. In addition, long-term monitoring would be conducted to ensure that the remedy is performing as anticipated. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately after remedial construction is completed. Based on natural recovery estimates, RAO 1 would be achieved in approximately 10 years through reduction in SWACs. RAO 2 would be achieved immediately after remedial construction is completed.

Alternative 10: ENR with MNR (10 Years). Alternative 10 would reduce surface sediment concentrations and immobilize COCs in DU N-2 through natural processes augmented with a thin layer of clean material:

- ENR would be implemented for areas with surface sediment COC concentrations exceeding the RAL_{10} criteria (670 µg/kg for total PCBs and 2.3 mg/kg for mercury).
- MNR would be implemented for areas with surface sediment COC concentrations between the RAL_0 (380 µg/kg for total PCBs and 1.4 mg/kg for mercury) and RAL_{10} criteria.
- AC amendment treatment would be implemented in under-pier areas with surface sediment COC concentrations exceeding the RAL_0 criteria (380 µg/kg for total PCBs and 1.4 mg/kg for mercury).

Approximately 2.5 feet of sediment may need to be removed by dredging before ENR material placement within navigation areas to gain clearance to avoid future disturbance to the ENR layer by maintenance dredging activities. However, this dredging volume is not part of the cost estimate; partial dredging is assumed to be performed by the maintenance dredging program. Clean material would be placed for ENR of a 1.6-acre area, MNR would be implemented over 14.2 acres, and AC amendment treatment would cover 0.7 acre beneath the Oscar 1 Pier. The total volume of ENR material required to implement this alternative is approximately 1,900 yd^3. Construction would take less than 1 month. The total cost is estimated at $1.9 million NPV. After 10 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary. ICs would continue to be maintained and modified as needed to ensure that buried contamination remains in place. Performance monitoring would be conducted to ensure that ENR is performing as anticipated. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately after remedial construction is completed. Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 10 years. RAO 2 would be achieved immediately after remedial construction is completed.

2.9.5 Summary of Retained Remedial Alternatives for DU N-3 (Off Ford Island Landfill and Camel Refurbishing Area)

All five of the remedial alternatives developed for DU N-3 were retained for detailed and comparative analysis:

- Alternative 1: No Action
- Alternative 2: MNR (achieve PRGs in 10 years)
- Alternative 3: Dredging
- Alternative 4: ENR
- Alternative 5: Capping

These alternatives are summarized in Table 2-17 and described below.

Table 2-17: DU N-3 (Off Ford Island Landfill and Camel Refurbishing Area) Summary of Retained Remedial Alternatives

Retained Remedial Alternative	Summary
1: No Action	• Retained as baseline for comparison to other alternatives per CERCLA requirement. • RAOs may potentially be achieved within 10 years based on natural recovery model. • Does not include ICs, monitoring, or contingency actions to achieve RAOs. • Total cost is $0.
2: MNR (Achieve PRGs in 10 Years)	• Monitoring ongoing natural recovery progress to reduce COC concentrations (4.5 acres). • RAOs may potentially be achieved within 10 years based on natural recovery model. • Total cost is $180,000 ($0 operational, $180,000 O&M).
3: Dredging	• Remove 1,500 yd^3 of surface sediment over 0.6 acres; placement of thin layer of clean material to address residual contamination. • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill. • RAOs would be achieved following construction (< 1 month). • Total cost is $650,000 ($633,000 capital; $17,000 O&M).
4: ENR	• Placement of thin layer of clean material in areas of moderate contamination areas to enhance natural recovery (0.6 acre). • RAOs would be achieved following construction (< 1 month). • Total cost $270,000 ($224,000 capital; $46,000 O&M).
5: Capping	• Placement of 3-foot cap of clean material (0.6 acre). • RAOs would be achieved following construction (< 1 month). • Total cost $580,000 ($540,000 capital; $40,000 O&M).

Note: Shaded cell indicates the preferred remedial alternative selected for the DU.

Alternative 1: No Action. The no action alternative is included in the screening evaluation as a baseline for comparison with the other remedial action alternatives in accordance with CERCLA. The alternative would require natural recovery to achieve RAOs over time. Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 10 years, and RAO 2 would be achieved in approximately 10 years. Alternative 1 includes no ICs, monitoring, or adaptive management to reduce risk or ensure achievement of RAOs. The total cost of this alternative is $0.

Alternative 2: MNR (10 Years). Alternative 2 would rely on natural recovery processes to reduce surface sediment COC concentrations to achieve PRGs and meet the RAOs over time. Based on baseline conditions and model predictions, the period required to achieve the PRGs by natural recovery is approximately 10 years. Monitoring events are assumed to occur in years 2, 5, and 10. After 10 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary. For the cost estimates, it is assumed that 5 percent of the footprint would require dredging as a contingency action.

MNR would apply to 4.5 acres of sediment with surface sediment COC concentrations exceeding the PRG for total PCBs (170 µg/kg). No dredging volume is associated with this alternative, although contingency actions could include removing contaminated sediment, or pre-dredging to fit a cap or ENR layer. The total cost is estimated at $180,000 NPV (not including costs for site-wide remedial goal monitoring, which are included in the cost estimate for DU SE-1).

During the recovery period, Alternative 2 would rely on ICs to prevent or limit exposure of human receptors to acceptable levels by restricting human access to the contaminated sediment, and limiting the potential for human consumption of fish, shellfish, and other aquatic organisms that may bioaccumulate the COCs. The Navy owns and controls access to the navigation channel and Ford Island shoreline adjacent to this DU; therefore, LUCs, access restrictions, and security measures are already in place. Public advisories regarding fish and shellfish consumption are posted along the shoreline. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately. Natural recovery estimates indicate that RAO 1 would be achieved through reduction in SWACs in approximately 10 years. RAO 2 would be achieved immediately.

Alternative 3: Dredging. Alternative 3 would reduce risk to human health and the environment by removing sediments in areas with surface sediment COC concentrations exceeding the RAL_0 criterion for total PCBs (470 µg/kg). Surface and subsurface sediments would be removed down to the maximum depth of RAL_0 exceedances. This alternative reduces the SWACs for the DU to levels below PRGs protective of both human health and the environment. The total dredging area is only 0.6 acre, and the average thickness of sediment to be dredged is 1 foot, for an estimated total removal volume of 1,500 yd^3. The total cost is estimated at $650,000 NPV.

The alternative would achieve RAO 1 and RAO 2 immediately after completion of the remedial construction activities. Alternative 3 includes ICs, monitoring, and adaptive management to ensure the achievement of RAOs.

Alternative 4: ENR. Alternative 4 would apply ENR to areas with surface sediment COC concentrations exceeding the RAL_0 criterion for total PCBs (470 µg/kg). ENR would be implemented over approximately 0.6 acre, with placement of approximately 730 yd^3 of clean material. Unlike DUs SE-1, N-2, and N-4, maintenance dredging does not affect DU N-3, and navigation clearances do not apply. The total cost is estimated at $270,000 NPV.

ICs would continue to be maintained and modified as needed to ensure that buried contamination remains in place. In addition, long-term monitoring would be conducted to ensure that ENR is performing as anticipated. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately after remedial construction is completed. RAO 2 would be achieved upon completion of remedial construction.

Alternative 5: Capping. Alternative 5 would place a conventional cap over surface sediment with total PCB concentrations exceeding the RAL_0 criterion (470 µg/kg). This alternative would reduce the SWACs for the DU to levels below PRGs protective of both human health and the environment immediately after completion of remedial construction.

The total area designated for capping is approximately 0.6 acre. No partial removal would be required prior to placement of cap material because DU N-3 contains no maintenance dredging or berthing areas. The total cost is estimated at $580,000 NPV. This alternative does not include partial removal in nearshore areas to ensure no net change in elevation (loss of water depth) after cap placement. This potential requirement can be assessed during remedial design, if needed.

ICs would continue to be maintained and modified as needed to ensure that buried contamination will remain in place. Long-term monitoring would be performed to ensure that the cap is functioning as anticipated. This alternative would achieve RAOs 1 and 2 immediately after construction.

Alternative 6 includes ICs, monitoring, and adaptive management to ensure the achievement of RAOs.

2.9.6 Summary of Retained Remedial Alternatives for DU N-4 (Bishop Point)

Five out of the six of the remedial alternatives developed for DU N-4 were retained for detailed and comparative analysis:

- Alternative 1: No Action
- Alternative 2: MNR with Continued Maintenance Dredging (30 years)
- Alternative 3: Dredging
- Alternative 4: ENR
- Alternative 6: Focused Dredging with MNR

These alternatives are summarized in Table 2-18 and described below.

Table 2-18: DU N-4 (Bishop Point) Summary of Retained Remedial Alternatives

Retained Remedial Alternative	Summary
1: No Action	• Retained as baseline for comparison to other alternatives per CERCLA requirement. • RAOs may potentially be achieved within 30 years based on natural recovery model. • Does not include ICs, monitoring, or contingency actions to achieve RAOs. • Total cost is $0.
2: MNR with Continued Maintenance Dredging	• Monitoring ongoing natural recovery progress to reduce COC concentrations (4.3 acres). • RAOs may potentially be achieved within 10 years based on natural recovery model. • Total cost is $260,000 ($0 operational, $260,000 O&M).
3: Dredging	• Remove 13,000 yd^3 of surface sediment over 2.7 acres; placement of thin layer of clean material to address residual contamination. • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill. • RAOs would be achieved following construction (< 1 month). • Total cost is $5.4M ($5.3M capital; $100,000 O&M).
4: ENR	• Placement of a thin layer of clean material to enhance natural recovery of sediments with moderate COC concentrations (0.7 acre); monitoring natural recovery progress in areas of lower contamination (1.5 acres). [a] • RAOs would be achieved following construction (< 1 month). • Total cost is $380,000 ($260,000 capital; $120,000 O&M). [b]
6: Focused Dredging with MNR	• Remove 9,100 yd^3 of surface sediment over 2.7 acres; placement of thin layer of clean material to address residual contamination; monitoring ongoing natural recovery progress to reduce COC concentrations (4.3 acres). • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill. • RAOs would be achieved in 10 years following construction. • Total cost is $3.9M ($3.85M capital; $0.5M O&M).

Note: Shaded cell indicates the preferred remedial alternative selected for the DU.
[a] Monitoring is implemented to address remnant areas excluded from ENR based on 2017 BOD data.
[b] The estimated cost of the preferred remedy was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

Alternative1: No Action. The no action alternative is included in the screening evaluation as a baseline for comparison with the other remedial action alternatives in accordance with CERCLA. This alternative would require approximately 30 years of natural recovery to achieve the PRGs and includes no adaptive management or monitoring to manage risks or ensure that RAOs are met. The total cost of this alternative is $0.

Alternative 2: MNR with Continued Maintenance Dredging (30 Years). Alternative 2 would rely on natural recovery processes to reduce surface sediment COC concentrations and associated human health and ecological risks to achieve PRGs over time. Based on baseline conditions and model predictions, the period required to achieve the PRGs by natural recovery is approximately 30 years. Monitoring events are assumed to occur in years 2, 5, and 10 and at 5-year intervals until the end of the 30-year period. After 30 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary. For the cost estimates, it is assumed that 5 percent of the footprint would require dredging as a contingency action.

MNR would apply to 4.3 acres of sediment with surface sediment COC concentrations exceeding the PRG. Although contingency action could be necessary, no dredging volume is associated with this alternative. The total cost is estimated at $260,000 NPV and does not include site-wide remedial goal monitoring (included in the cost estimate for DU SE-1).

Alternative 2 would not require ICs to limit human consumption of fish because the existing baseline conditions meet RAO 1, therefore RAO 1 would be achieved immediately. RAO 2 would be achieved in approximately 30 years.

Alternative 3: Dredging. Alternative 3 would reduce risks to human health and the environment by removing sediments with concentrations exceeding RAL_0 criteria (420 mg/kg for lead and 1,200 mg/kg for zinc). Dredging would remove an estimated 13,000 yd^3 of sediments from a 2.7-acre section of the DU. Approximately 1,600 yd^3 of clean materials would be placed to cover dredge residuals (50 percent of the dredge footprint). Construction activities are estimated to require less than 1 month. The total cost is estimated at $5.4 million NPV. The alternative would achieve RAOs 1 and 2 immediately after completion of the remedial construction activities. Alternative 3 includes ICs, monitoring, and adaptive management to ensure the achievement of RAOs.

Alternative 4: ENR. Alternative 4 would isolate and immobilize COCs in DU N-4 through natural processes augmented with a thin layer of clean material and active material such as AC (if necessary). ENR would be implemented for areas with surface sediment COC concentrations exceeding RAL_0 criteria (420 mg/kg for lead and 1,200 mg/kg for zinc). Approximately 2.5 feet of sediment could require partial dredging prior to ENR material placement to avoid future disturbance by maintenance dredging activities. However, this dredging volume is not part of the cost estimate; partial dredging is assumed to be performed by the maintenance dredging program.

ENR would be implemented over 0.7 acre. Approximately 900 yd^3 of clean materials (i.e., sand and AC) would be placed. MNR will be implemented over 1.5 acres. The total cost is estimated at $380,000 NPV. ICs would continue to be maintained and modified as needed to ensure that buried contamination remains in place. Performance monitoring would be conducted to ensure that ENR is performing as anticipated.

ENR remediation would reduce risks in the short term, and achieve all RAOs within approximately 20 years. RAO 1 would be achieved immediately after remedial construction is completed. RAO 2 would be achieved in approximately 20 years.

Alternative 6: Focused Dredging with MNR (10 Years). Alternative 6 would achieve the RAOs by dredging surface sediments with lead concentrations exceeding the RAL_{10} criterion (720 mg/kg), and implementing MNR for areas with COC concentrations between the RAL_0 and RAL_{10} criteria (420 mg/kg and 720 mg/kg, respectively, for lead, and greater than 1,200 mg/kg for zinc).

2.7 acres of DU N-4 is designated for dredging under this alternative (same as Alternative 3, although this alternative has higher RAL criteria). The Thiessen polygon interpolation method does not have sufficient resolution to distinguish between these different RAL concentrations. Although MNR is also included in this alternative, COC concentrations within the range of RALs specified for MNR have not been reported for sediment samples collected from this DU. Therefore, the acreage, volumes, cost, and performance estimate for Alternative 6 are essentially the same as those for Alternative 3; however, the actual dredging volume required to implement this alternative is likely to be less than that required for Alternative 3. To account for this factor, the dredge volume has been reduced by 30 percent compared to Alternative 3 (further refinement of concentration gradients will be required to address this issue in the design phase). This anticipated lower dredging volume for Alternative 6 compared to Alternative 3 is factored into the ranking of alternatives in the comparative analysis below. The total cost is estimated at $3.9 million NPV. After 10 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary.

The PRGs would be achieved in 10 years. ICs would continue to be maintained and modified as needed to ensure that buried contamination will remain in place. Active remediation by dredging would reduce risks in the short term, and natural recovery would further reduce risks to achieve all RAOs over time. RAO 1 would be achieved immediately after remedial construction is completed. Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 10 years. Based on SWAC calculations, RAO 2 would be achieved when remedial construction is completed; however, the alternative is designed to meet RAO 2 in 10 years.

2.9.7 Summary of Retained Remedial Alternatives for DU E-2 (Off Waiau Power Plant)

Five out of the nine of the remedial alternatives developed for DU E-2 were retained for detailed and comparative analysis:

- Alternative 1: No Action
- Alternative 2: MNR (achieve PRGs in 30 years)
- Alternative 7: Focused Capping with ENR
- Alternative 8: Focused Dredging with MNR (achieve PRGs in 10 years)
- Alternative 9: Focused Capping with ENR and MNR (achieve PRGs in 10 years)

These alternatives are summarized in Table 2-19 and described below.

Table 2-19: DU E-2 (Off Waiau Power Plant) Summary of Retained Remedial Alternatives

Retained Remedial Alternative	Summary
1: No Action	• Retained as baseline for comparison to other alternatives per CERCLA requirement. • RAOs may potentially be achieved within 30 years based on natural recovery model. • Does not include ICs, monitoring, or contingency actions to achieve RAOs in the long-term. • Total cost is $0.
2: MNR (achieve PRGs in 30 years)	• Monitoring ongoing natural recovery progress to reduce COC concentrations (227 acres). • RAOs may potentially be achieved within 30 years based on natural recovery model. • Total cost is $580,000 ($0 operational, $580,000 O&M).
7: Focused Capping with ENR	• Placement of 3-foot cap of clean material in areas with higher contamination (4.8 acres); placement of thin layer of clean material in areas of moderate contamination areas to enhance natural recovery (3.9 acres). • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill. • RAOs achieved immediately following construction (approximately < 1 month). • Total cost $6.2M ($5.7M capital; $0.5M O&M).
8: Focused Dredging with MNR (Achieve PRGs in 10 Years)	• Removal of sediments with high COC concentrations (1.5 acres; 7,500 yd^3); monitoring of natural recovery progress for sediments with lower concentrations (7.2 acres). • Disposal of dredge material in the SOODMDS, a confined aquatic disposal site in Pearl Harbor, an on-island landfill, or an off-island landfill, depending on the COC concentrations. • RAOs achieved in approximately 10 years following construction. • Total cost $3.4M ($3.1M capital; $0.3M O&M). [a]
9: Focused Capping with ENR, and MNR (achieve PRGs in 10 years)	• Placement of 3-foot cap of clean material in areas with higher contamination (3.2 acres); placement of thin layer of clean material in areas of moderate contamination areas (1.6 acres) to enhance natural recovery; monitoring in areas of lower contamination (3.9 acres). • RAOs achieved in approximately 10 years following construction. • Total cost $3.9M ($3.4M capital; $0.5M O&M).

Note: Shaded cell indicates the preferred remedial alternative selected for the DU.
[a] The estimated cost of the preferred remedy was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

Alternative 1: No Action. The no action alternative is included in the screening evaluation as a baseline for comparison with the other remedial action alternatives in accordance with CERCLA. The alternative would require natural recovery to achieve RAOs over time:

- Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 30 years.
- RAO 2 would be achieved in approximately 20 years.
- RAO 3 would be achieved in approximately 30 years.

Alternative 1 includes no ICs, monitoring, or adaptive management to reduce risk or ensure the achievement of RAOs. The total cost of this alternative is $0.

Alternative 2: MNR (Achieve PRGs in 30 Years). Alternative 2 would rely on natural recovery processes to reduce surface sediment COC concentrations and associated human health and ecological risks to achieve PRGs over time. Based on baseline conditions and model predictions, the period required to achieve the PRGs by natural recovery is approximately 30 years. Monitoring events are assumed to occur in years 2, 5, and 10, and every 5 years for 30 years. After 30 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary. For the cost estimates, it is assumed that 5 percent of the footprint would require dredging as a contingency action.

MNR would apply to 11.1 acres of sediment with surface sediment PCB concentrations exceeding the PRG (110 µg/kg). No dredging volume is associated with this alternative, although contingency actions could include dredging, as well as capping or ENR. The total cost is estimated at $580,000 NPV and does not include site-wide remedial goal monitoring (included in the cost estimate for DU SE-1).

During the recovery period, Alternative 2 would rely on ICs to prevent or limit exposure of human receptors to acceptable levels by restricting human access to the contaminated sediment, and limiting the potential for human consumption of fish, shellfish, and other aquatic organisms that may bioaccumulate the COCs. Although the Navy owns and controls access to all the submerged portions of Pearl Harbor, the onshore area adjacent to DU E-2 is occupied by an electrical power plant owned and operated by HECO; therefore, additional IC and source control measures may be required to implement this alternative. Public advisories regarding fish and shellfish consumption are posted along the shoreline; however, this alternative would not address pathways for exposure of ecological receptors.

If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately. Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 30 years. RAO 2 would be achieved in approximately 20 years and RAO 3 would be achieved in approximately 30 years.

Alternative 7: Focused Capping with ENR. Alternative 7 would isolate and immobilize contaminated sediments in DU E-2 by placing conventional sand caps over surface sediments with the highest PCB concentrations, and ENR material over surface sediments with lower concentrations:

- Capping would be implemented in all areas where total PCB concentrations in surface sediments exceed 2 × the RAL_0 criterion (540 µg/kg).
- ENR would be implemented in all areas where total PCB concentrations in surface sediments are between the RAL_0 criterion and 2 × the RAL_0 criterion (270–540 µg/kg for total PCBs).

The need for partial removal prior to capping nearshore or a modified cap design nearshore to ensure no significant loss of water depth nearshore would be assessed during remedial design if needed. 4.8 acres of the 8.7-acre area designated for active remediation would be capped; ENR material would be placed over the remaining 3.9 acres. The total volume of cap and ENR material required to implement this alternative is approximately 32,000 yd^3. The total cost is estimated at $6.2 million NPV.

ICs would continue to be maintained and modified as needed to ensure that buried contamination will remain in place. Long-term monitoring would be performed to ensure that the remedies are functioning as anticipated and maintenance and repairs would be performed as needed. Alternative 7 would achieve RAOs 1, 2, and 3 immediately after construction is completed. This alternative includes ICs, monitoring, and adaptive management to ensure the achievement of RAOs.

Alternative 8: Focused Dredging with MNR. Alternative 8 would achieve the RAOs through a combination of MNR, focused dredging, and ICs:

- Dredging would remove contaminated sediment from portions of DU E-2 where surface sediment COC concentrations exceed the RAL_{10} criterion for total PCBs (470 µg/kg). The dredging would extend down to the depths required to remove subsurface sediments with concentrations exceeding the RAL_0 criterion.
- Portions of the DU where total PCB concentrations in surface sediment are greater than the RAL_0 criterion (270 µg/kg) but less than the RAL_{10} criterion (470 µg/kg) would be addressed with MNR.

Dredging would remove contaminated sediments from a 1.5-acre area, while MNR would be implemented for a 7.2-acre area. The total sediment removal volume is approximately 7,500 yd^3. Approximately 900 yd^3 of clean materials would be placed to cover dredge residuals. Construction is estimated to take less than 1 month. The total costs are estimated at $3.4 million NPV.

Like Alternative 2, the goal for MNR is to achieve the PRGs, but the PRGs would be achieved in 10 years. After 10 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary. ICs would continue to be maintained and modified as needed to ensure that buried contamination will remain in place. In addition, long-term monitoring would be conducted to ensure that the remedy is performing as anticipated.

If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately. Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 10 years. RAO 2 would be achieved immediately after remedial construction is completed and RAO 3 would be achieved in approximately 10 years.

Alternative 9: Focused Capping with ENR and MNR. Alternative 9 would isolate and immobilize contaminated sediments in DU E-2 by placing conventional sand caps over areas with the highest surface sediment PCB concentrations, and implement ENR remediation for areas with moderate surface sediment concentrations, with MNR for areas with the lowest surface sediment concentrations:

- Capping would be implemented in areas where total PCB concentrations in surface sediment exceed 2 × the RAL_{10} criterion (940 µg/kg).
- ENR would be implemented in areas where total PCB concentrations in surface sediment are between the RAL_{10} criterion (470 µg/kg) and 2 × the RAL_{10} criterion (940 µg/kg).
- MNR would be implemented in areas where total PCB concentrations in surface sediment are between the RAL_0 criterion (270 µg/kg) and the RAL_{10} criterion (470 µg/kg).

MNR would be implemented over a 10-year period; it would address only the areas with the lowest PCB concentrations. The total surface area for active remediation is 4.8 acres. Capping would be implemented over 3.2 acres, ENR over 1.6 acres, and MNR over 3.9 acres. The total volume of material required for capping and ENR remediation is approximately 20,000 yd^3. The total cost is estimated at $3.9 million NPV. After 10 years, if the PRGs have not been met, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary.

ICs would continue to be maintained and modified as needed to ensure that buried contamination will remain in place. Long-term monitoring would be performed to ensure that the remedies are functioning as anticipated and maintenance and repairs would be performed as needed. If ICs are effective to limit fish consumption to protective levels, then human health protection would be achieved immediately. Based on natural recovery estimates, RAO 1 would be achieved through reduction in SWACs in approximately 10 years. RAO 2 would be achieved immediately after remedial construction is completed.

2.9.8 Summary of Retained Remedial Alternatives for DU E-3 (Aiea Bay)

Four out of the six of the remedial alternatives developed for DU E-3 were retained for detailed and comparative analysis:

- Alternative 1: No Action
- Alternative 2: MNR (achieve PRGs in 10 years)
- Alternative 5: ENR
- Alternative 6: Capping

These alternatives are summarized in Table 2-20 and described below.

Table 2-20: DU E-3 (Aiea Bay) Summary of Retained Remedial Alternatives

Retained Remedial Alternative	Summary
1: No Action	• Retained as baseline for comparison to other alternatives per CERCLA requirement. • RAOs are currently achieved; background-based threshold concentration may potentially be achieved within 10 years based on natural recovery model. • Does not include ICs, monitoring, or contingency actions to achieve PRGs. • Total cost is $0.
2: MNR (Achieve PRG in 10 Years)	• Monitoring ongoing natural recovery progress to reduce COC concentrations (73.5 acres). • RAOs are currently achieved; background-based threshold concentration may potentially be achieved within 10 years based on natural recovery model. • Total cost is $2.4M ($0 operational, $2.4M O&M).
5: ENR	• Placement of thin layer of clean material in areas of moderate contamination areas to enhance natural recovery (30 acres). • RAOs are currently achieved; background-based PRGs would be achieved following implementation (< 1 month). • Total cost $12M ($11M capital; $1M O&M).
6: Capping	• Placement of 3-foot cap of clean material (30 acres). • RAOs are currently achieved; background-based PRGs would be achieved following implementation (< 1 month). • Total cost $28M ($27M capital; $1M O&M).

Note: Shaded cell indicates the preferred remedial alternative selected for the DU.

Alternative 1: No Action. The no action alternative is included in the screening evaluation as a baseline for comparison with the other remedial action alternatives in accordance with CERCLA. The available data suggest that the SWACs are currently low enough to meet the applicable RAOs for this DU (RAOs 1 and 2) with no action; however, this alternative includes no ICs, monitoring, or contingency measures to manage risk or ensure that the RAOs are achieved over the long term. The total cost of this alternative is $0.

Alternative 2: MNR (Achieve PRGs in 10 Years). Alternative 2 would rely on natural recovery processes to reduce surface sediment COC concentrations and associated human health and ecological risks. Based on baseline conditions and model predictions for DU E-3, natural recovery would be sufficient to achieve PRGs in approximately 10 years. Monitoring events are assumed to occur in years 2, 5, and 10. If the monitoring data indicate that natural recovery is not proceeding as expected, then contingency actions such as ENR, capping, dredging, or further monitoring would be evaluated and implemented as necessary. For the cost estimates, it is assumed that 5 percent of the footprint would require dredging as a contingency action.

MNR would apply to 73.5 acres of sediment with surface sediment COC concentrations exceeding the RAL developed for this DU (1.7 mg/kg for mercury). No dredging volume is associated with this alternative, although contingency actions could include dredging, capping, or ENR. The total cost is estimated at $2.4 million NPV (not including the cost of site-wide remedial goal monitoring, which is included in the cost estimate for DU SE-1).

Alternative 2 would utilize ICs to prevent or limit exposure of human receptors to acceptable levels by reducing the potential for human consumption of fish and marine organisms that may bioaccumulate the COCs. Although the Navy owns and controls access to all the submerged portions of Pearl Harbor, portions of the onshore area adjacent to DU E-3 are currently open to the public; therefore, additional IC measures would be required to implement this alternative. Public advisories regarding fish and shellfish consumption are posted along the shoreline; however, this alternative would not address pathways for exposure of ecological receptors. SWACs for this DU are already low enough to meet the applicable RAOs for this DU (RAOs 1 and 2) but may not be currently low enough in shallow waters to meet RAO 3.

Alternative 5: ENR. Alternative 5 applies ENR to areas with concentrations in surface sediment exceeding the RAL (1.7 mg/kg for mercury). ENR would be implemented over 30 acres. Approximately 36,000 yd^3 of clean materials would be placed. Maintenance dredging does not affect DU E-3, and navigation clearances do not apply. The total cost is estimated at $12 million NPV.

ICs would continue to be maintained and modified as needed to ensure that buried contamination remains in place. In addition, long-term monitoring would be conducted to ensure that ENR is performing as anticipated. The applicable RAOs for this DU (RAOs 1 and 2) would be achieved immediately upon completion of remedial construction.

Alternative 6: Capping. Alternative 6 would include placement of a conventional cap over areas with surface sediment COC concentrations exceeding the RAL (1.7 mg/kg for mercury). The total area designated for capping under this alternative is approximately 30 acres. The total volume of material required for capping is approximately 170,000 yd^3. The total cost is estimated at $28 million NPV.

ICs would continue to be maintained and modified as needed to ensure that buried contamination will remain in place. Long-term monitoring would be performed to ensure that the caps are functioning as required to provide adequate protection. The RAOs would be achieved immediately upon completion of remedial construction.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

2.10.1 Evaluation Criteria

The RA alternatives were evaluated using the nine criteria specified by the NCP (40 CFR 300.430[e][a][iii]) and the EPA *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988). The nine evaluation criteria are listed in Table 2-21.

Table 2-21: NCP Criteria for Analysis of Response Action Alternatives

Criterion	Considerations
Threshold Criteria	
Overall Protectiveness of Public Health and the Environment	Protection from unacceptable risks posed by hazardous substances, pollutants, or contaminants.
Compliance with ARARs	Compliance with requirements under federal, state, and local environmental laws.
Primary Balancing Criteria	
Long-Term Effectiveness and Permanence	Continued protection of human health and the environment after completion of the remedy.
Reduction of Toxicity, Mobility, or Volume Through Treatment	Permanent or significant reduction of the toxicity, mobility, or volume of constituents through treatment.
Short-Term Effectiveness	Protection of human health and the environment during implementation of the remedy.
Implementability	Technical and administrative feasibility and availability of services and materials.
Cost	Capital and annual operations and maintenance costs and their net present value.
Modifying Criteria	
State Agency Acceptance	EPA and DOH have concurred with preferred remedial alternatives presented in the FS.
Public Acceptance	Community participation, input, and support.

2.10.2 Detailed Comparative Analysis of Alternatives

This section presents the detailed comparative analysis of the remedial alternatives for each DU. For the threshold criteria, each alternative was evaluated for compliance with ARARs and overall protectiveness. For the primary balancing criteria, each alternative was evaluated against the criteria of effectiveness, implementability, and cost using a five-tiered scale (poor, fair, good, very good, and excellent) for each criterion according to the ability of the alternative to achieve the objectives of the criterion. The ratings were then compared to assess the relative performance of each RA alternative to facilitate identification of a recommended remedial alternative for the site. The cost estimates were developed in accordance with the USACE and EPA guidance *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USACE and EPA 2000). Details of the cost estimate and supplied costs provided in the FS report, Appendix H (DON 2015), meet EPA requirements for FS-level cost estimates, and are consistent with those prepared for projects similar to the Pearl Harbor Sediment FS.

2.10.2.1 Comparative Analysis of Alternatives for DU SE-1 (Southeast Loch)

Summary of the comparative analysis of retained remedial alternatives against the NCP nine criteria for DU SE-1 is presented in Table 2-22. The complete detailed evaluation and comparative analysis is presented in Table 2-23.

Table 2-22: DU SE-1 (Southeast Loch) Summary of Comparative Analysis of Remedial Alternatives

Criterion	Considerations
Overall Protection of Human Health and the Environment	The performance of the remedial alternatives for Overall Protection is split between those alternatives that rely more on natural recovery (Alternatives 1, 2, 5, 10, 12, and 13) and those that rely less on natural recovery (Alternatives 3 and 8) to achieve the RAOs. The challenges to natural recovery in DU SE-1 include an active maintenance dredging program, relatively high COC concentrations in surface sediment, and source control. Alternative 1 does not address any of these challenges. Alternative 2 includes ICs and adaptive management, which reduce risks to human health in the short term and provide a mechanism for contingency remediation in the future. Alternatives 5, 10, 12, and 13 significantly reduce COC concentrations in sediment immediately after remedial construction is completed, and isolate or treat hotspots with high COC concentrations. Alternative 3 does not rely on natural recovery; however, it significantly reduces risk immediately after remedial construction is completed. Alternative 8 includes a natural recovery component, but only for areas with lower COC concentrations in surface sediment.
Compliance with ARARs	Alternative 1 does not comply with ARARs because it does not include ICs, monitoring, or contingency actions to meet RAOs. The other alternatives comply with ARARs by achieving RAOs through a combination of active remediation, ICs, natural recovery, and/or adaptive management.
Long-Term Effectiveness and Permanence	Uncontrolled sources pose a risk to the long-term effectiveness and permanence of any remedy; therefore, a source control strategy will be implemented along with the sediment remedy. Alternatives 1 and 2 leave subsurface sediment with elevated COC concentrations in place, where it could be potentially exposed in the future, and rely heavily on seafood consumption advisories for protection of human health. Alternative 5 includes active remediation, but leaves buried contamination on site under thin layers of clean sediment and limits reliance on seafood consumption advisories. Alternatives 10, 12, and 13 include capping of the highest concentrations (with partial removal of hotspots to gain clearance in navigation areas) and/or include treatment with AC amendment to limit bioavailability of COCs, specifically PCBs, and limit reliance on seafood consumption advisories. Alternatives 3 and 8 remove sediment with high COC concentrations or isolate it under engineered caps, and minimize the need for seafood consumption advisories.
Reduction of Toxicity, Mobility, or Volume through Treatment	Alternatives 1, 2, and 5 do not meet this criterion. Alternatives 3, 8, and 10 would not include treatment unless the dredged material is treated prior to disposal. Alternatives 12 and 13 involve placement of AC amendment that reduces toxicity and mobility of the COCs by binding contaminants and limiting bioavailability.
Short-Term Effectiveness	Alternative 3 includes high construction-related impacts to the environment, society, and economy, but would require a relatively short period to achieve the RAOs. Alternative 1 does not create construction-related impacts but would not achieve the RAOs. Alternative 2 does not create construction-related impacts to the environment, society, and economy, but requires 30 years to achieve RAOs. Construction-related impacts are relatively low or moderate for Alternatives 5, 8, 10, 12, and 13; however, these alternatives would require extended periods (10–20 years) to achieve RAOs.
Implementability	Alternative 1 is readily implementable. Alternative 2 uses natural processes to aid remediation, thus limiting requirements for sediment removal or material placement. Alternative 3 presents large challenges with removal and disposal of large volumes of sediment due to constructability challenges for removing deep sediments along the piers and limited disposal options (limited CAD and CDF capacity, lack of an on-island Subtitle C landfill, and very limited capacity in the on-island Subtitle D landfill. Alternatives 8, 10, and 12 present moderate challenges during construction. Alternatives 5 and 13 present fewer challenges during construction, based on the requirements for dredging and/or placement of material in the harbor.
Cost	Estimated costs range up to $470 million, with a significant degree of uncertainty based on the method of disposal, explosives safety requirements for dredging, and the source of capping or ENR material. Costs do not include upland remediation or additional source control.

Table 2-23: DU SE-1 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation			Alternative 1: No Action	Alternative 2: MNR with Continued Maintenance Dredging (30 Years)	Alternative 3: Dredging	Alternative 5: ENR	Alternative 8: Focused Capping and Partial Dredging with ENR	Alternative 10: Focused Capping and Partial Dredging with ENR and MNR (10 years)	Alternative 12: Focused Capping and Partial Dredging with ENR, AC, and MNR (20 years)	Alternative 13: Focused Dredging with ENR, AC, and MNR (20 years)
Threshold Criteria	*Overall Protection of Human Health and Environ-ment*	RAO 1 (human health – seafood consumption)	Risks would remain elevated for approximately 30 years. No ICs or adaptive management to further reduce risks.	With ICs (fish consumption advisories), risk reduction would be achieved immediately. Based on SWACs, risks would remain elevated for approximately 30 years. Natural recovery and adaptive management would reduce risks.	RAO 1 would be achieved following construction (3 years).	With ICs (fish consumption advisories), risk reduction would be achieved immediately. Based on SWACs, risks would remain elevated for approximately 10 years. Natural recovery and adaptive management would reduce risks.	RAO 1 would be achieved following construction (1 year).	With ICs (fish consumption advisories), risk reduction would be achieved immediately. Based on SWACs, risks would remain elevated for approximately 10 years. Natural recovery and adaptive management would reduce risks.	With ICs (fish consumption advisories), risk reduction would be achieved immediately. Based on SWACs, risks would remain elevated for approximately 20 years. Natural recovery and adaptive management would reduce risks.	With ICs (fish consumption advisories), risk reduction would be achieved immediately. Based on SWACs, risks would remain elevated for approximately 20 years. Natural recovery and adaptive management would reduce risks.
		RAO 2 (ecological health – bottomfish)	Risks would remain elevated for approximately 10 years. No monitoring or adaptive management to ensure risk reduction.	Risks would remain elevated for approximately 10 years. Natural recovery and adaptive management would ensure risk reduction.	RAO 2 would be achieved following construction (3 years).	RAO 2 would be achieved following construction (1 year).	RAO 2 would be achieved following construction (1 year).	RAO 2 would be achieved following construction (1 year).	RAO 2 would be achieved following construction (1 year).	RAO 2 would be achieved following construction (1 year).
		RAO 3 (ecological health – waterbirds) applicable to areas less than 2 meters (6.6 feet) water depth	Not applicable to this DU (DU SE-1 includes only a small area with water depths less than 2 meters).	Not applicable to this DU (DU SE-1 includes only a small area with water depths less than 2 meters).	Not applicable to this DU (DU SE-1 includes only a small area with water depths less than 2 meters).	Not applicable to this DU (DU SE-1 includes only a small area with water depths less than 2 meters).	Not applicable to this DU (DU SE-1 includes only a small area with water depths less than 2 meters).	Not applicable to this DU (DU SE-1 includes only a small area with water depths less than 2 meters).	Not applicable to this DU (DU SE-1 includes only a small area with water depths less than 2 meters).	Not applicable to this DU (DU SE-1 includes only a small area with water depths less than 2 meters).
		Meets Criterion?	**No.** Risks associated with exposure to contaminated surface sediments would remain unacceptable for many years, and the potential for future exposure of contaminated subsurface sediments (e.g., due to erosion and dredging) would remain elevated.	**Yes.** Risks would remain elevated for a significant period, and the potential for future exposure of contaminated subsurface sediments (e.g., due to erosion and dredging) would remain elevated. Monitoring and adaptive management would improve long-term effectiveness.	**Yes.** Removal of contaminated sediment would minimize the need for monitoring, ICs, and adaptive management.	**Yes.** Risk would remain elevated for a moderate period after ENR is implemented. Monitoring and adaptive management would improve permanence.	**Yes.** Risks would remain elevated for a moderate period. Capping is an engineered remedy that significantly reduces the potential for future exposure of contaminated sediments; however, contingency actions may be needed to ensure that the cap remains effective over the long-term. Sediments with relatively high COC concentrations would be capped or dredged, while sediments with lower concentrations would be treated with ENR.	**Yes.** Risks would remain elevated for a moderate period. Capping and dredging are engineered remedies that significantly reduce the potential for future exposure of contaminated sediments. ENR and MNR are less-robust ECs, but would be effective for areas with lower levels of contamination.	**Yes.** Risks would remain elevated for a moderate period. Capping and dredging are engineered remedies that significantly reduce the potential for future exposure of contaminated sediments. ENR, AC, and MNR are less-robust ECs, but would be effective for areas with lower levels of contamination.	**Yes.** Risks would remain elevated for a moderate period. Focused dredging for removal of contaminated sediment would minimize the need for monitoring, ICs, and adaptive management. ENR, AC, and MNR are less-robust ECs, but would be effective for areas with lower levels of contamination. Monitoring and adaptive management would improve permanence.
	Compliance with ARARs and TBCs: Meets Criterion?		**No.** No chemical-specific criteria are ARARs for Pearl Harbor sediment; however, this alternative would not achieve the chemical-specific risk-based TBC criteria developed for Pearl Harbor or comply with CERCLA requirements for protection of human health and the environment.	**Yes.** Would comply with ARARs by protecting human health and the environment over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for maintenance of the ICs or during potential contingency actions.	**Yes.** Would comply with ARARs by protecting human health and the environment following construction. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for maintenance of the ICs or during potential contingency actions.	**Yes.** Would comply with ARARs by protecting human health and the environment following construction. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.

Table 2-23: DU SE-1 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation				Alternative 1: No Action	Alternative 2: MNR with Continued Maintenance Dredging (30 Years)	Alternative 3: Dredging	Alternative 5: ENR	Alternative 8: Focused Capping and Partial Dredging with ENR	Alternative 10: Focused Capping and Partial Dredging with ENR and MNR (10 years)	Alternative 12: Focused Capping and Partial Dredging with ENR, AC, and MNR (20 years)	Alternative 13: Focused Dredging with ENR, AC, and MNR (20 years)
Balancing Criteria	*Long-Term Effective-ness and Perma-nence*	Magnitude of residual risk	Risk Remaining in Surface Sediment.	Long period of elevated risk (30 years) and no ICs, monitoring, or adaptive management to further reduce risks or ensure protectiveness.	Long period of elevated risk (30 years).	Short period of elevated risk (3 years).	Risk would remain elevated for approximately 10 years.	Short period of elevated risk (1 year).	Risks would remain elevated for approximately 10 years.	Risks would remain elevated for approximately 20 years but bioavailability would be limited by ENR and AC amendment application.	Risks would remain elevated for approximately 20 years, but bioavailability would be limited by AC amendment application.
			Potential risk from exposure of subsurface sediment contamination. Evaluation based on the potential impact of exposure of subsurface contamination and the chance of exposure.	Large area with subsurface contamination exceeding RAL_0 (173 acres). Potential for exposure through maintenance dredging or vessel scour is high.	Large area with subsurface contamination exceeding RAL_0 (173 acres). Potential for exposure through maintenance dredging or vessel scour is high. Monitoring and adaptive management would measure and improve long-term effectiveness.	Small area with subsurface contamination exceeding RAL_0 (13 acres of under-pier capping plus 11 acres where subsurface sediment >RAL_0 and surface sediment is <RAL_0). Potential for exposure is low; caps would be engineered and monitored.	Large area with subsurface contamination exceeding RAL_0 (173 acres). Potential for exposure through maintenance dredging or vessel scour is moderate. Contamination would be left under a thin (6-inch) layer of clean material (149 acres). In-situ AC amendment treatment in under-pier areas would be engineered to be stable (13 acres). Monitoring and adaptive management would measure and improve long-term effectiveness.	Large area with subsurface contamination exceeding RAL_0 (150 acres). Potential for exposure through maintenance dredging or vessel scour is low-moderate. Full (23 acres) dredging or partial dredging (35 acres) would be performed. Highly contaminated areas would be under engineered caps (35 acres). Low-moderately contaminated areas would be under ENR (91 acres). In-situ AC amendment treatment in under-pier areas would be engineered to be stable (13 acres). Monitoring and adaptive management would measure and improve long-term effectiveness.	Large area with subsurface contamination exceeding RAL_0 (157 acres). Potential for exposure through maintenance dredging or vessel scour is low-moderate. Full dredging (16 acres) or partial dredging (21 acres) would be performed. Highly contaminated areas would be under engineered caps (21 acres). Moderately contaminated areas would be under ENR (42 acres). Low contamination in MNR areas (70 acres). In-situ AC amendment treatment g in under-pier areas would be engineered to be stable (13 acres). Monitoring and adaptive management would measure and improve long-term effectiveness.	Large area with subsurface contamination exceeding RAL_0 (170 acres). Potential for exposure through maintenance dredging or vessel scour is moderate. Full dredging (3 acres) or partial dredging (2 acres) would be performed. Highly contaminated areas would be under engineered caps (2 acres). Moderately contaminated areas would be under ENR (34 acres). Low-moderate contamination in MNR areas (119 acres). In-situ AC amendment treatment in under-pier areas would be engineered to be stable (8 acres). Monitoring and adaptive management would measure and improve long-term effectiveness.	Large area with subsurface contamination exceeding RAL_0 (170 acres). Potential for exposure through maintenance dredging is moderate. Full dredging (2 acres) would be performed. Moderately contaminated areas would be under ENR (12.6 acres). Areas of low-moderate contamination would be under MNR (139 acres). In-situ AC amendment treatment in under-pier areas would be engineered to be stable (8 acres). Monitoring and adaptive management would measure and improve long-term effectiveness.
		Adequacy and reliability of controls	Application of engineering and institutional controls.	Would involve no engineering or institutional controls.	Would involve no ECs. Seafood consumption advisories would reduce risk, but require voluntary adherence.	Would minimize the need for engineering and institutional controls.	ENR is an engineered remedy, but less-robust than capping or dredging. Therefore, the reliability of ECs would be moderate. Seafood consumption advisories would reduce risk, but require voluntary adherence.	Reliability of ECs (partial dredging and capping) would be excellent for sediments with relatively high COC concentrations, and good for sediments with lower concentrations (ENR). Reliability of deed restrictions to limit future dredging would be good. Reliance on seafood consumption advisories would be reduced.	Reliability of ECs (partial dredging and capping) would be excellent for sediments with relatively high COC concentrations, and good for sediments with moderate concentrations (ENR), but relatively poor for sediments with low concentrations (MNR). Reliability of ICs (deed restrictions to limit future dredging) would be good.	Reliability of ECs (partial dredging and capping) would be excellent for sediments with relatively high COC concentrations, and good for sediments with moderate concentrations (ENR and AC), but relatively poor for sediments with low concentrations (MNR). Reliability of ICs (deed restrictions to limit future dredging) would be good.	Reliability of ECs (focused dredging) would be excellent for sediments with relatively high COC concentrations, and good for sediments with moderate concentrations (ENR and AC), but relatively poor for sediments with low concentrations (MNR). Reliability of ICs (deed restrictions to limit future dredging) would be good.

Table 2-23: DU SE-1 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation			Alternative 1: No Action	Alternative 2: MNR with Continued Maintenance Dredging (30 Years)	Alternative 3: Dredging	Alternative 5: ENR	Alternative 8: Focused Capping and Partial Dredging with ENR	Alternative 10: Focused Capping and Partial Dredging with ENR and MNR (10 years)	Alternative 12: Focused Capping and Partial Dredging with ENR, AC, and MNR (20 years)	Alternative 13: Focused Dredging with ENR, AC, and MNR (20 years)
Balancing Criteria		*Rating:*	**Poor.** Risks associated with exposure to contaminated surface sediments would remain unacceptable for many years, and the potential for future exposure of contaminated subsurface sediments (e.g., due to erosion and dredging) would remain elevated.	**Fair.** Risks would remain elevated for a significant period, and the potential for future exposure of contaminated subsurface sediments (e.g., due to erosion and dredging) would remain elevated. Monitoring and adaptive management would improve long-term effectiveness.	**Excellent.** Removal of contaminated sediment would minimize the need for monitoring, ICs, and adaptive management.	**Good.** Risk would remain elevated for a moderate period after ENR is implemented. Monitoring and adaptive management would improve permanence.	**Very Good.** Risks would remain elevated for a moderate period. Capping and partial dredging would significantly reduce the potential for future exposure of contaminated sediments; however, contingency actions may be needed to ensure that the cap remains effective over the long-term. Sediments with relatively high COC concentrations would be capped or dredged, while sediments with lower concentrations would be treated with ENR.	**Very Good** Risks would remain elevated for a moderate period. Capping and partial dredging would significantly reduce the potential for future exposure of contaminated sediments; however, contingency actions may be needed to ensure that the cap remains effective over the long-term. Sediments with relatively high COC concentrations would be capped or dredged, while sediments with lower concentrations would be remediated with ENR or MNR.	**Very Good.** Risks would remain elevated for a moderate period. Capping and partial dredging would significantly reduce the potential for future exposure of contaminated sediments; however, contingency actions may be needed to ensure that the cap remains effective over the long-term. Sediments with relatively high COC concentrations would be capped or dredged, while sediments with lower concentrations would be remediated with ENR, AC, or MNR.	**Very Good.** Focused dredging for removal of hot spots (sediments with the highest COC concentrations) would minimize the need for monitoring, ICs, and adaptive management. ENR and MNR provide less-robust ECs but would be effective for sediments with lower levels of contamination.
	Reduction of Toxicity, Mobility, or Volume through Treatment		**Poor.** Would not reduce toxicity, mobility, or volume through treatment.	**Poor.** Would not include treatment.	**Fair.** Would not include treatment unless dredged material is treated prior to disposal to reduce the toxicity, mobility, or volume of COCs.	**Poor.** Would not include treatment.	**Fair.** Would not include treatment unless dredged material is treated prior to disposal to reduce the toxicity, mobility, or volume of COCs.	**Fair.** Would not include treatment unless dredged material is treated prior to disposal to reduce the toxicity, mobility, or volume of COCs.	**Good.** In-situ treatment with AC amendment would reduce toxicity and mobility of bioaccumulating COCs.	**Good.** In-situ treatment with AC amendment would reduce toxicity and mobility of bioaccumulating COCs.
	Short-Term Effective-ness	Area or benthic habitat disturbed (dredging plus capping area) (acres)	0	0	149	0	58	37	5	2
		Time the water column is disturbed (construction period) (years)	0	0	3	1	1	1	1	1
		CO_2/Air pollutant emissions during construction (metric tons)	0/0	0/0	13,000/140	930/4	5,000/45	3,300/28	690/4	450/4
		Worker injuries during construction	0	0	8.6	1.1	3.9	2.5	0.7	0.6
		Volume of contaminated sediment disposed of (yd^3)	0	0	1,200,000	0	320,000	220,000	28,000	17,000
		Volume of material placed (yd^3)	0	0	120,000	210,000	350,000	210,000	87,000	36,000
		Time to achieve all RAOs	RAO 1 and RAO 2: may not be achieved. RAO 3: not applicable.	RAO 1: 30 years. RAO 2: 10 years. RAO 3: not applicable.	RAO 1 and RAO 2: post-construction (3 years). RAO 3: not applicable.	RAO 1 and RAO 2: approximately 10 years. RAO 3: not applicable.	RAO 1 and RAO 2: post-construction (1 year). RAO 3: not applicable.	RAO 1 and RAO 2: approximately 10 years. RAO 3: not applicable.	RAO 1 and RAO 2: approximately 20 years. RAO 3: not applicable.	RAO 1 and RAO 2: approximately 20 years. RAO 3: not applicable.
		Rating:	**Fair.** Would create no impacts due to construction, but RAOs may not achieved.	**Good.** Would create no impacts due to construction, but would take many years to achieve the RAOs.	**Fair.** Dredging is labor and energy intensive and disrupts the existing environment. Time to achieve RAOs would be short (3 + 3 = 6 yrs) compared to alternatives that rely on MNR.	**Good.** Minimal impacts from construction, moderate time to achieve RAOs.	**Good.** Would create moderate impacts during construction. Time to achieve RAOs would be short (3 + 1 = 4 yrs).	**Good.** Would have low impacts during construction. Time to achieve RAOs would be moderate.	**Good.** Low impacts during construction. Time to achieve RAOs would be longer.	**Good.** Low impacts during construction. Time to achieve RAOs would be longer.

Table 2-23: DU SE-1 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation			Alternative 1: No Action	Alternative 2: MNR with Continued Maintenance Dredging (30 Years)	Alternative 3: Dredging	Alternative 5: ENR	Alternative 8: Focused Capping and Partial Dredging with ENR	Alternative 10: Focused Capping and Partial Dredging with ENR and MNR (10 years)	Alternative 12: Focused Capping and Partial Dredging with ENR, AC, and MNR (20 years)	Alternative 13: Focused Dredging with ENR, AC, and MNR (20 years)
Balancing Criteria	*Implement-ability*	Administrative implementability	Not likely to gain agency approval.	Would present few administrative challenges.	Would present large administrative challenges associated with disposal of dredged material, and with procurement of placement material (1,400,000 yd^3 total).	Would present administrative challenges with procurement of placement material (210,000 yd^3 total). Could require significant repairs in maintenance dredging areas if ENR layer is removed.	Would present large administrative challenges associated with disposal of dredged material, and with procurement of placement material (670,000 yd^3 total). Would require deed restrictions in navigational areas if capped to ensure that the maintenance dredging depth is not increased, resulting in a breach of the cap, or cap would require maintenance following dredging activities.	Would present large administrative challenges associated with disposal of dredged material, and with procurement of placement material (430,000 yd^3 total). Would require deed restrictions in navigational areas if capped to ensure that the maintenance dredging depth is not increased, resulting in a breach of the cap, or cap would require maintenance following dredging activities.	Would present moderate administrative challenges associated with disposal of dredged material, and with procurement of placement material (130,000 yd^3 total). Would require deed restrictions in navigational areas if capped to ensure that the maintenance dredging depth is not increased, resulting in a breach of the cap.	Would present relatively lower administrative challenges associated with disposal of dredged material, and with procurement of placement material (36,000 yd^3 total).
		Technical implementability (reliability of technology and recontamination potential)	Not applicable.	Would be simple to implement initially, but more challenging during monitoring and potential adaptive management if the natural recovery rate is not sufficient to achieve the RAOs within a reasonable time frame.	Contamination depth is >8 feet near structures, which would be technically challenging to remove. Overwater structures would present structural, access, and sediment stability challenges.	Would be relatively simple to implement during construction, but more challenging during monitoring, repair, and adaptive management. Overwater structures would present structural, access, and sediment stability challenges.	Capping and ENR would be relatively straightforward to implement, but design requires attention to location-specific conditions such as currents, concentrations, and groundwater flux; and cap design considerations such as material specifications, carbon or reactive material content, armoring and grain size, thickness, and placement techniques. Overwater structures would present structural, access, and sediment stability challenges.	Capping and ENR would be relatively straightforward to implement, but design requires attention to location-specific conditions such as currents, concentrations, and groundwater flux; and cap design considerations such as material specifications, carbon or reactive material content, armoring and grain size, thickness, and placement techniques. Contamination depth is >8 feet near structures, which would be technically challenging to remove. Overwater structures would present structural, access, and sediment stability challenges.	Capping, ENR and AC amendment would be relatively straightforward to implement, but design requires attention to location-specific conditions such as currents, concentrations, and groundwater flux; and cap design considerations such as material specifications, carbon or reactive material content, armoring and grain size, thickness, and placement techniques. Contamination depth is >8 feet near structures, which would be technically challenging to remove. Overwater structures would present structural, access, and sediment stability challenges.	ENR and AC amendment would be relatively simple to implement during construction, but future monitoring, repair, and adaptive management could require significant effort. Overwater structures would present structural, access, and sediment stability challenges.
		Availability of services and materials	Not applicable.	Would require few services or materials.	Would present challenges with availability of materials associated with disposal of dredged material, and with procurement of placement material (1,400,000 yd^3 total).	Would present challenges associated with procurement of placement material (210,000 yd^3 total).	Would present challenges associated with availability of materials for disposal of dredged material, and with procurement of placement material (670,000 yd^3 total).	Would present challenges associated with availability of materials for disposal of dredged material, and with procurement of placement material (430,000 yd^3 total).	Would present challenges associated with availability of materials for disposal of dredged material, and with procurement of placement material (130,000 yd^3 total).	Would present challenges associated with availability of materials for disposal of dredged material, and with procurement of placement material (36,000 yd^3 total).
		Rating:	**Excellent.** The alternative presents no implementability challenges.	**Excellent.**	**Fair.** Involves large removal and placement volumes, and constructability challenges for deep sediments near piers.	**Very Good.** Would be relatively simple to implement initially; potential future repairs would present additional challenges.	**Good.** Would present significant challenges during construction.	**Good.** Would present moderate challenges during construction.	**Good.** Would present moderate challenges during construction.	**Very Good.** Would present relatively lower challenges during construction.
	Cost	Net present value	$0	$10 million	$470 million	$76 million	$210 million	$140 million	$49 million	$31.4 million [a]
		Rating:	**Excellent.**	**Excellent.**	**Poor.**	**Good.**	**Fair.**	**Fair.**	**Very Good.**	**Very Good.**

CO_2 carbon dioxide
EC engineering control
Note: Ratings are based on a 5-tier scale: poor, fair, good, very good, excellent. Ratings were determined by comparison to other alternatives.
[a] The estimated cost of the preferred remedy (Alternative 13) was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

2.10.2.2 COMPARATIVE ANALYSIS OF ALTERNATIVES FOR DU N-2 (OSCAR 1 AND 2 PIERS SHORELINE)

Summary of the comparative analysis of retained remedial alternatives against the NCP nine criteria for DU N-2 (Oscar 1 and 2 Piers Shoreline) is presented in Table 2-24. The complete detailed evaluation and comparative analysis is presented in Table 2-25.

Table 2-24: DU N-2 (Oscar 1 and 2 Piers Shoreline) Summary of Comparative Analysis of Remedial Alternatives

Criterion	Considerations
Overall Protection of Human Health and the Environment	The performance of the remedial alternatives for Overall Protection is split between the alternatives that rely more on natural recovery to achieve PRGs (Alternatives 1, 2, 8, and 10) and an alternative that relies less on natural recovery (Alternative 3). However, in contrast to other DUs, DU N-2 has much lower COC concentrations, thus improving the viability of the alternatives that incorporate natural recovery. Alternative 1 does not meet this criterion because it does not include ICs, monitoring, or contingency actions. Alternatives 2, 8, and 10 rely on natural recovery, but include ICs, monitoring, and contingency actions to reduce risks and ensure that RAOs are met in the long term. Alternative 3 achieves significant reduction in COC concentrations immediately after remedial construction is completed.
Compliance with ARARs	Alternative 1 does not comply with ARARs because it does not include ICs, monitoring, or contingency actions to meet remediation targets. The other alternatives comply with ARARs by achieving RAOs through a combination of active remediation, ICs, natural recovery, and/or adaptive management.
Long-Term Effectiveness and Permanence	Alternatives 1 and 2 leave subsurface sediment with elevated COC concentrations in place, where it could be potentially exposed in the future, and rely heavily on seafood consumption advisories for protection of human health. Alternative 10 leaves sediment with high COC concentrations on site, but also includes in-place treatment of sediments in the under-pier areas and relies less on seafood consumption advisories. Alternatives 3 and 8 remove most of the more impacted sediment from the harbor and rely less on seafood consumption advisories.
Reduction of Toxicity, Mobility, or Volume through Treatment	Alternatives 1, 2, and 10 do not meet this criterion. Alternatives 3 and 8 do not include treatment unless the dredged material is treated prior to disposal. Treatment amendments reduce the toxicity and mobility of the COCs by limiting bioavailability and preventing transport in both the dissolved and solid phases.
Short-Term Effectiveness	Alternative 1 does not create construction-related impacts but would not achieve the RAOs. Alternative 3 would quickly achieve the RAOs, but includes high construction-related impacts. Alternative 2 does not create impacts, but would require 20 years to achieve RAOs. Alternatives 8 and 10 would achieve RAOs in 10 years with minimal impacts.
Implementability	Alternative 1 is simple and readily implementable. Alternative 2 uses natural processes to aid remediation, thus limiting requirements for sediment removal and material placement. Alternative 3 involves removal and disposal of large volumes of sediments from areas where recontamination is likely to occur if ongoing contaminant sources are not controlled prior to or during the remedial construction. Alternatives 8 and 10 use natural sediment remediation processes with limited material placement or sediment removal.
Cost	Estimated costs range up to $60 million to complete the in-water sediment remedies, and do not include costs for upland remediation or source control measures. The major cost uncertainties are the method for dredged material disposal, explosives safety requirements for dredging, and the source of material for capping or ENR remedies.

Table 2-25: DU N-2 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation				Alternative 1: No Action	Alternative 2: MNR with Continued Maintenance Dredging (20 Years)	Alternative 3: Dredging	Alternative 8: Focused Dredging with MNR (10 years)	Alternative 10: ENR with MNR (10 years)
Threshold Criteria	*Overall Protection of Human Health and Environment*	RAO 1 (human health – seafood consumption)		Risks would remain elevated for approximately 20 years. No ICs or adaptive management to further reduce risks.	RAO 1 would be achieved in the short term with ICs, and in the long term (approximately 20 years) through natural recovery and/or adaptive management.	RAO 1 would be achieved following construction (5 months).	With ICs (fish consumption advisories), risk reduction would be achieved immediately. Based on SWACs, risks would remain elevated for approximately 10 years. Natural recovery and adaptive management would reduce risks.	With ICs (fish consumption advisories), risk reduction would be achieved immediately. Based on SWACs, risks would remain elevated for approximately 10 years. Natural recovery and adaptive management would reduce risks.
		RAO 2 (ecological health – bottomfish)		RAO 2 would be achieved immediately.	RAO 2 would be achieved immediately.	RAO 2 would be achieved following construction (5 months).	RAO 2 would be achieved following construction (<1 month).	RAO 2 would be achieved following construction (<1 month).
		RAO 3 (ecological health – waterbirds) applicable to areas less than 2 meters (6.6 feet) water depth		Not applicable to DU N-2 (very few areas are shallower than 2 meters water depth).	Not applicable to DU N-2 (very few areas are shallower than 2 meters water depth).	Not applicable to DU N-2 (very few areas are shallower than 2 meters water depth).	Not applicable to DU N-2 (very few areas are shallower than 2 meters water depth).	Not applicable to DU N-2 (very few areas are shallower than 2 meters water depth).
		Meets Criterion?		**No.** Long period of elevated risks (20 years) and no ICs or adaptive management to further reduce risks or ensure protectiveness.	**Yes.** Risks would remain elevated for approximately 20 years.	**Yes.** All RAOs would be achieved post-construction (5 months).	**Yes.** Risks would remain elevated for approximately 10 years.	**Yes.** Risks would remain elevated for approximately 10 years.
	Compliance with ARARs and TBCs: Meets Criterion?			**No.** No chemical-specific criteria are ARARs for Pearl Harbor sediment; however, this alternative would not achieve the chemical-specific risk-based TBC criteria developed for Pearl Harbor or comply with CERCLA requirements for protection of human health and the environment.	**Yes.** Would comply with ARARs by protecting human health and the environment over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for maintenance of the ICs or during potential contingency actions.	**Yes.** Would comply with ARARs by protecting human health and the environment following construction. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment following construction. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for maintenance of the ICs or during potential contingency actions.
Balancing Criteria	*Long-Term Effectiveness and Permanence*	Magnitude of residual risk	Risk Remaining in Surface Sediment	Risks would remain elevated for approximately 20 years and no ICs, monitoring.	Risks would remain elevated for approximately 20 years.	Short period of elevated risk (5 months).	Risks would remain elevated for approximately 10 years.	Risks would remain elevated for approximately 10 years.
			Potential risk from exposure of subsurface sediment contamination. Evaluation based on the potential impact of exposure of subsurface contamination and the chance of exposure.	Large area with subsurface contamination exceeding RAL_0 (16.7 acres). Potential for exposure through maintenance dredging or vessel scour is high.	Large area with subsurface contamination exceeding RAL_0 (16.7 acres). Potential for exposure through maintenance dredging or vessel scour is high. Monitoring and adaptive management would measure and improve long-term effectiveness.	Small area with subsurface contamination remaining at depth or in under-pier areas. Potential for exposure is low.	Some areas with subsurface contamination exceeding RAL_0 (12 acres of MNR, 0.7 acre of under-pier capping). MNR would be used in areas with lower concentrations of contamination, and hotspot areas would be dredged. Potential for exposure through maintenance dredging or vessel scour is moderate. In-situ AC amendment treatment in under-pier areas would be engineered to be stable). Monitoring and adaptive management would measure and improve long-term effectiveness.	Large area with subsurface contamination exceeding RAL_0 (16.7 acres). Potential for exposure through maintenance dredging or vessel scour is moderate. Contamination would be left under a thin (6-inch) layer of clean material (1.6 acres). In-situ AC amendment treatment in under-pier areas would be engineered to be stable (0.7 acre). Monitoring and adaptive management would measure and improve long-term effectiveness.
		Adequacy and reliability of controls	Application of engineering and institutional controls	Would involve no engineering or institutional controls.	Would involve no ECs. Seafood consumption advisories would reduce risk, but require voluntary adherence.	Would minimize the need for engineering and institutional controls.	Reliability of ECs would be unnecessary in areas where higher concentrations have been dredged. Poor in areas of less contamination (MNR).	ENR is an engineered remedy, but less robust than capping or dredging. Therefore, the reliability of ECs would be moderate. Seafood consumption advisories would reduce risk, but require voluntary adherence.
		Rating:		**Poor.** Would not reduce risks to human health or the environment to acceptable levels, nor provide the ICs or contingency actions required to further reduce risks.	**Fair.** Risks would remain elevated for a significant period, and contaminated subsurface sediments would remain on site. Monitoring and adaptive management would improve long-term effectiveness.	**Fair.** Risks would remain elevated for a significant period, and contaminated subsurface sediments would remain on site. Monitoring and adaptive management would improve long-term effectiveness.	**Very Good.** Risks would remain elevated for a moderate period. Focused dredging would completely remove hotspot contamination from the DU. MNR would be used to remediate sediments with lower levels of contamination.	**Very Good.** Risks would remain elevated for a moderate period. ENR would reduce the bioavailability of COCs but would not isolate the contaminated sediments. Monitoring and adaptive management would improve permanence.
	Reduction of Toxicity, Mobility, or Volume through Treatment			**Poor.** Would not reduce toxicity, mobility, or volume through treatment.	**Poor.** Would not include treatment.	**Fair.** Would not include treatment unless dredged material is treated prior to disposal to reduce the toxicity, mobility, or volume of COCs.	**Fair.** Would not include treatment unless dredged material is treated prior to disposal to reduce the toxicity, mobility, or volume of COCs.	**Poor.** Would not include treatment.

Table 2-25: DU N-2 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation			Alternative 1: No Action	Alternative 2: MNR with Continued Maintenance Dredging (20 Years)	Alternative 3: Dredging	Alternative 8: Focused Dredging with MNR (10 years)	Alternative 10: ENR with MNR (10 years)
Balancing Criteria	*Short-Term Effective-ness*	Area or benthic habitat disturbed (dredging plus capping area) (acres)	0	0	16 acres	4	0
		Time the water column is disturbed (construction period) (years)	0	0	5 months	1 month	<1 month
		CO_2/Air pollutant emissions during construction (metric tons)	0/0	0/0	2,100/35	520/9	16/0
		Worker injuries during construction	0	0	1.0	0.2	0.02
		Volume of contaminated sediment disposed of (yd^3)	0	0	150,000	30,000	0
		Volume of material placed (yd^3)	0	0	11,000	4,100	3,600
		Time to achieve all RAOs	RAO 1 and RAO 2: would not be achieved for at least 20 years. RAO 3: not applicable.	RAO 1: 20 years. RAO 2: 0 years. RAO 3: not applicable.	RAO 1 and RAO 2: post-construction (5 months). RAO 3: not applicable.	RAO 1 and RAO 2: approximately 10 years. RAO 3: not applicable.	RAO 1: approximately 10 years. RAO 2: post-construction. RAO 3: not applicable.
		Rating:	**Fair.** Would create no impacts due to construction, but RAOs would not be achieved for at least 20 years.	**Fair.** Would create no impacts due to construction, but require a long period to achieve RAOs. Sedimentation rates are low, and recovery could take longer than predicted. Other recovery mechanisms besides sediment burial could contribute to recovery (e.g., maintenance dredging).	**Poor.** Dredging is labor- and energy-intensive and disrupts the existing environment. Time achieve RAOs would be short compared to other alternatives.	**Fair.** Would create no impacts due to construction, but would require a relatively long period to achieve RAOs. Sedimentation rates are low, and recovery could take longer than predicted. Other recovery mechanisms besides sediment burial could contribute to recovery (i.e., maintenance dredging).	**Very Good.** Minimal impacts from construction, moderate time to achieve RAOs.
	Implement-ability	Administrative implementability	Not likely to gain agency approval.	Would present few administrative challenges.	Would present large administrative challenges associated with disposal of dredged material, and with procurement of placement material (160,000 yd^3 total).	Would present large administrative challenges associated with disposal of dredged material, and with procurement of placement material (35,000 yd^3 total).	Would present administrative challenges with procurement of placement material (3,600 yd^3 total). Could require significant repairs in maintenance dredging areas if ENR layer is removed.
		Technical implementability (reliability of technology and recontamination potential)	Not applicable	Would be simple to implement initially, and more challenging during monitoring and potential adaptive management if RAOs are not achieved in the long term. Recontamination potential would be managed adaptively with contingency actions as needed. This alternative would allow time for source control efforts to be completed.	Dredging is relatively straightforward to implement, but disposal of dredge material can be challenging. Overwater structures would present structural, access, and sediment stability and constructability challenges near piers. Ongoing sources (e.g., active dry dock area and other upland operations) may continue to impact sediments in this DU, resulting in moderate to high recontamination potential. Low recontamination potential from scour events.	Dredging is relatively straightforward to implement. Overwater structures would present structural, access, and sediment stability challenges. This alternative would be effective to control recontamination. The potential for exposure of subsurface contamination would be managed by removing the most contaminated sediments, and adaptively managing remaining areas with moderate potential for recontamination due to ongoing sources.	Would be relatively simple to implement during construction, but more challenging during monitoring repair, and adaptive management. Overwater structures would present structural, access, and sediment stability challenges. Recontamination potential is moderate to high in localized areas near storm drain inputs but can be adaptively managed. Scour processes could lead to exposure of buried contamination near berthing areas (but water is relatively deep and data show minimal scour potential).
		Availability of services and materials	Not applicable	Would require few services or materials.	Would present challenges with availability of materials associated with disposal of dredged material, and with procurement of placement material (160,000 yd^3 total).	Would present challenges with disposal of dredged material, and with procurement of placement material (35,000 yd^3 total).	Would present less challenges associated with procurement of placement material (3,600 yd^3 total).
		Rating:	**Excellent.** The alternative presents no implementability challenges.	**Excellent.**	**Poor.**	**Very Good.**	**Very Good.**
	Cost	Net present value	$0	$1.0 million	$60 million	$13 million	$1.9 million [a]
		Rating:	**Excellent.**	**Excellent.**	**Poor.**	**Good.**	**Excellent.**

Note: Ratings are based on a 5-tier scale: poor, fair, good, very good, excellent. Ratings were determined by comparison to other alternatives.
[a] The estimated cost of the preferred remedy (Alternative 10) was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

2.10.2.3 COMPARATIVE ANALYSIS OF ALTERNATIVES FOR DU N-3 (OFF FORD ISLAND LANDFILL AND CAMEL REFURBISHING AREA)

Summary of the comparative analysis of retained remedial alternatives against the NCP nine criteria for DU N-3 (Off Ford Island Landfill and Camel Refurbishing Area) is presented in Table 2-26. The complete detailed evaluation and comparative analysis is presented in Table 2-27.

Table 2-26: DU N-3 (Off Ford Island Landfill and Camel Refurbishing Area) Summary of Comparative Analysis of Remedial Alternatives

Criterion	Considerations
Overall Protection of Human Health and the Environment	The performance of the remedial alternatives for Overall Protection is split between the alternatives that rely more on natural recovery to achieve RAOs (Alternatives 1 and 2) and the alternatives that rely less on natural recovery (Alternatives 3, 4, and 5). Alternative 1 does not meet this criterion because it does not include ICs, monitoring, or contingency actions. Alternative 2 relies on natural recovery, but includes ICs, monitoring, and contingency actions to reduce risks over the recovery period and ensure that the RAOs are met in the long term. Alternatives 3, 4, and 5 would achieve RAOs immediately after remedial construction is completed.
Compliance with ARARs	Alternative 1 does not comply with ARARs because it does not include ICs, monitoring, or contingency actions to meet remediation targets. The other alternatives comply with ARARs by achieving RAOs through a combination of active remediation, ICs, natural recovery, and/or adaptive management.
Long-Term Effectiveness and Permanence	Alternatives 1 and 2 have a high potential for future exposure of subsurface sediment contamination and rely heavily on seafood consumption advisories for protection of human health. Alternative 4 includes ECs and relies less on seafood consumption advisories. Alternatives 3 and 5 remove the contaminated sediment or provide an engineered cap to isolate and protect it from future disturbance, and limit the need for seafood consumption advisories.
Reduction of Toxicity, Mobility, or Volume through Treatment	Alternatives 1, 2, 4, and 5 do not meet this criterion. Alternative 3 does not include treatment unless the dredged material is treated prior to disposal. Treatment amendments reduce the toxicity and mobility of the COCs by limiting bioavailability and preventing transport in both the dissolved and solid phases.
Short-Term Effectiveness	Although Alternative 1 does not create impacts, it would not achieve RAOs. Alternatives 3 and 5 would quickly achieve the RAOs and have additional short-term impacts related to dredge residuals, but this would be mitigated by placement of clean material imported to the site. Alternative 2 does not create construction-related impacts, but would require 10 years to achieve RAOs. Alternative 4 would achieve RAOs after remedial construction is complete, with relatively low construction and energy impacts.
Implementability	Alternative 1 is simple and readily implementable. Alternatives 2 and 4 use natural processes to aid remediation, thus limiting requirements for sediment removal and material placement. Alternatives 3 and 5 involve removal or placement of moderate volumes of sediment or cap materials, have moderate potential for localized recontamination after remediation due to ongoing lateral sources (including one large storm drain), and would require coordination with other entities before beginning remediation.
Cost	Estimated costs range up to $650K to complete the in-water sediment remedies, and do not include costs for upland remediation or source control. The two major cost uncertainties are the method for dredged material disposal and the source of material for capping or ENR remediation.

Table 2-27: DU N-3 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation				Alternative 1: No Action	Alternative 2: MNR (10 Years)	Alternative 3: Dredging	Alternative 4: ENR	Alternative 5: Capping
Threshold Criteria	*Overall Protection of Human Health and Environment*	RAO 1 (human health – seafood consumption)		Risks would remain elevated for approximately 10 years. No ICs or adaptive management to further reduce risks.	Risks would remain elevated for approximately 10 years. No ICs or adaptive management to further reduce risks.	RAO 1 would be achieved following construction (<1 month).	RAO 1 would be achieved following construction (<1 month).	RAO 1 would be achieved following construction (<1 month).
		RAO 2 (ecological health – bottomfish)		RAO 2 would be achieved immediately.	RAO 2 would be achieved immediately.	RAO 2 would be achieved following construction (<1 month).	RAO 2 would be achieved following construction (<1 month).	RAO 2 would be achieved following construction (<1 month).
		RAO 3 (ecological health – waterbirds) applicable to areas less than 2 meters (6.6 feet) water depth		Not applicable to DU N-3 (area shallower than 2 meters water depth is unsuitable habitat for waterbirds).	Not applicable to DU N-3 (area shallower than 2 meters water depth is unsuitable habitat for waterbirds).	Not applicable to DU N-3 (area shallower than 2 meters water depth is unsuitable habitat for waterbirds).	Not applicable to DU N-3 (area shallower than 2 meters water depth is unsuitable habitat for waterbirds).	Not applicable to DU N-3 (area shallower than 2 meters water depth is unsuitable habitat for waterbirds).
		Meets Criterion?		**No.** Moderate period of elevated risks (10 years) and no ICs or adaptive management to further reduce risks or ensure protectiveness.	**Yes.** Moderate period of elevated risks (10 years) and with ICs or adaptive management to further reduce risks.	**Yes.** RAO 1 and RAO 2 would be achieved post-construction (<1 month); RAO 3 is not applicable.	**Yes.** RAO 1 and RAO 2 would be achieved post-construction (<1 month); RAO 3 is not applicable.	**Yes.** RAO 1 and RAO 2 would be achieved post-construction (<1 month); RAO 3 is not applicable.
	Compliance with ARARs and TBCs: Meets Criterion?			**No.** No chemical-specific criteria are ARARs for Pearl Harbor sediment; however, this alternative would not achieve the chemical-specific risk-based TBC criteria developed for Pearl Harbor or comply with CERCLA requirements for protection of human health and the environment.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.
	Meets Threshold Requirements?			No	Yes	Yes	Yes	Yes
Balancing Criteria	*Long-Term Effectiveness and Permanence*	Magnitude of residual risk	Risk Remaining in Surface Sediment	Risks would remain elevated for approximately 10 years, and no ICs, monitoring, or adaptive management to further reduce risks or ensure protectiveness.	Risks would remain elevated for approximately 10 years.	Short period of elevated risk (<1 month).	Short period of elevated risk (<1 month).	Short period of elevated risk (<1 month).
			Potential risk from exposure of subsurface sediment contamination. Evaluation based on the potential impact of exposure of subsurface contamination and the chance of exposure.	Large area of subsurface sediments with PCB concentrations exceeding RAL_0 (0.6 acre). Potential for exposure is low, through erosion and vessel scour.	Would leave subsurface sediments with PCB concentrations exceeding RAL_0 in place (0.6 acre). Potential for exposure is low, through erosion and vessel scour.	Would not leave subsurface sediments with COC concentrations exceeding the RALs in place.	Would leave subsurface sediments with PCB concentrations exceeding RAL_0 in place (0.6 acre). Potential for exposure is low. Monitoring and adaptive management would measure and improve long-term effectiveness.	Would leave subsurface sediments with PCB concentrations exceeding RAL_0 in place (0.6 acre). Potential for exposure is low. Contamination would be isolated under an engineered cap. Monitoring and adaptive management would measure and improve long-term effectiveness.
		Adequacy and reliability of controls	Application of engineering and institutional controls	Would involve no engineering or institutional controls.	Would involve no ECs. Seafood consumption advisories would reduce risk, but require voluntary adherence.	Would minimize the need for engineering and institutional controls.	ENR is an engineered remedy, but is less robust than capping or dredging. Therefore, the reliability of ECs would be moderate.	Reliability of ECs (isolation capping and O&M) would be excellent, and reliability of ICs (deed restrictions) would be good.
		Rating:		**Poor.** Would not reduce risks to human health or the environment to acceptable levels, nor provide the ICs or contingency actions required to further reduce risks.	**Fair.** Risks would remain elevated for a significant period, and contaminated subsurface sediments would remain on site. Monitoring and adaptive management would improve long-term effectiveness.	**Excellent.** Removal of contaminated sediment minimizes the need for monitoring, ICs, and adaptive management.	**Very Good.** Risks would remain elevated for a significant period, and contaminated subsurface sediments would remain on site. Monitoring and adaptive management would improve long-term effectiveness.	**Very Good.** Capping is an engineered remedy that significantly reduces the potential for future exposure of contaminated sediments; however, contingency actions may be needed to ensure that the cap remains effective over the long-term.
	Reduction of Toxicity, Mobility, or Volume through Treatment			**Poor.** Would not reduce toxicity, mobility, or volume through treatment.	**Poor.** Would not include treatment unless contingency actions use treatment technology.	**Fair.** Would not include treatment unless dredged material is treated prior to disposal to reduce the toxicity, mobility, or volume of COCs.	**Poor.** Would not include treatment.	**Poor.** Would not include treatment.

Table 2-27: DU N-3 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation			Alternative 1: No Action	Alternative 2: MNR (10 Years)	Alternative 3: Dredging	Alternative 4: ENR	Alternative 5: Capping
Balancing Criteria	*Short-Term Effective-ness*	Area or benthic habitat disturbed (dredging plus capping area) (acres)	0	0	0.6	0	0.6
		Time the water column is disturbed (construction period) (years)	0	0	<1 month	<1 month	<1 month
		CO_2/Air pollutant emissions during construction (metric tons)	0/0	0/0	34/0.73	14/0.4	31/0.61
		Worker injuries during construction	0	0	0.03	0.01	0.02
		Volume of contaminated sediment disposed of (yd^3)	0	0	1,500	0	0
		Volume of material placed (yd^3)	0	0	360	730	3,400
		Time to achieve all RAOs	May not be achieved.	RAO 1: 10 years. RAO 2: 0 years. RAO 3: not applicable.	RAO1, RAO 2, RAO 3: following construction (<1 month).	RAO1, RAO 2, RAO 3: following construction (<1 month).	RAO1, RAO 2, RAO 3: following construction (<1 month).
		Rating:	**Fair.** Would not create impacts due to construction, but RAOs may not be achieved.	**Good.** Good short-term effectiveness. Would create no impacts due to construction, with a moderate period to achieve RAOs.	**Fair.** Dredging is labor and energy intensive and disrupts the existing environment. Time achieve RAOs would be short.	**Very Good.** Minimal impacts from construction, short time to achieve RAOs.	**Fair.** Would create moderate impacts during construction. Time to achieve RAOs would be short.
	Implement-ability	Administrative implementability	Not likely to gain agency approval.	Would present few administrative challenges.	Would present administrative challenges associated with disposal of dredged material, and with procurement of placement material (1,900 yd^3 total).	Would present administrative challenges with procurement of placement material (730 yd^3 total).	Would present few administrative challenges associated with procurement of placement material (3,400 yd^3 total).
		Technical implementability (reliability of technology and recontamination potential)	Not applicable.	Would be simple to implement initially, and would provide time to complete source control efforts, but would be more challenging during monitoring and potential contingency actions. Sedimentation rates are low, suggesting that recovery could take longer than expected. Recontamination potential would be managed adaptively with contingency actions as needed. This alternative would allow time for source control efforts to be completed.	Technical challenges to dredging would be few in this DU, however, contamination is only 1 ft thick and dredging may create more construction-related impacts compared to the benefit of removing the sediment. Low recontamination potential from disturbance event (no berthing or navigation channel areas). Recontamination potential from lateral sources is low to moderate and very localized (no stream inputs, PCBs detected in received sediment near one storm drain).	Would be relatively simple to implement during construction, but more challenging during monitoring and potential contingency actions. Recontamination potential would be adaptively managed.	Capping is relatively straightforward to implement, but design requires attention to location-specific conditions such as currents, concentrations, and groundwater flux; and cap design considerations such as material specifications, carbon or reactive material content, armoring and grain size, thickness, and placement techniques. Low to moderate recontamination potential from lateral sources. May need to coordinate timing of cleanup with source control efforts.
		Availability of services and materials	Not applicable.	Would require few services or materials.	Would present challenges with availability of materials associated with disposal of dredged material, and with procurement of placement material (1,900 yd^3 total).	Would present challenges associated with procurement of placement material (730 yd^3 total).	Would present challenges with availability of materials associated with procurement of placement material (3,400 yd^3 total).
		Rating:	**Excellent.** The alternative presents no implementability challenges.	**Excellent.**	**Fair.** Involves large removal and placement volumes. Coordination with upland source control evaluation needed.	**Very Good.** Would be relatively simple to implement initially, but potential future contingency actions present additional challenges.	**Fair.** Would present challenges during construction associated with material placement and transportation, and recontamination potential.
	Cost	Net present value	$0	$180,000	$650,000	$270,000	$580,000
		Rating:	**Excellent.**	**Excellent.**	**Fair.**	**Very Good.**	**Good.**

Note: Ratings are based on a 5-tier scale: poor, fair, good, very good, excellent. Ratings were determined by comparison to other alternatives.

2.10.2.4 COMPARATIVE ANALYSIS OF ALTERNATIVES FOR DU N-4 (BISHOP POINT)

Summary of the comparative analysis of retained remedial alternatives against the NCP nine criteria for DU N-4 (Bishop Point) is presented in Table 2-28. The complete detailed evaluation and comparative analysis is presented in Table 2-29.

Table 2-28: DU N-4 (Bishop Point) Summary of Comparative Analysis of Remedial Alternatives

Criterion	Considerations
Overall Protection of Human Health and the Environment	The performance of the remedial alternatives for Overall Protection is split between the alternatives that rely more on natural recovery to achieve PRGs (Alternatives 1, 2, 4, and 6) and the alternative that relies less on natural recovery (Alternative 3). Alternative 1 (no action) does not meet this criterion because it does not include ICs, monitoring, or contingency actions. Alternatives 2, 4, and 6 rely on natural recovery, but include ICs, monitoring, and contingency actions to reduce risks and ensure that RAOs are met in the long term. Alternative 3 (dredging) reduces risk immediately after remedial construction is completed.
Compliance with ARARs	Alternative 1 does not comply with ARARs because it does not include ICs, monitoring, or contingency actions to meet remediation targets. The other alternatives comply with ARARs by achieving RAOs through a combination of active remediation, ICs, natural recovery, and/or adaptive management.
Long-Term Effectiveness and Permanence	Alternatives 1 and 2 leave subsurface sediment with elevated COC concentrations in place, where it could be potentially exposed in the future, and rely heavily on seafood consumption advisories for protection of human health. Alternatives 4 and 6 leave impacted subsurface sediment in place but address it with ECs (placement of a thin clean fill layer or remove sediments with highest COC concentrations). Alternative 3 removes the contaminated sediment and limits the need for seafood consumption advisories.
Reduction of Toxicity, Mobility, or Volume through Treatment	Alternatives 1, 2, and 4 do not meet this criterion. Alternatives 3 and 6 do not include treatment unless the dredged material is treated prior to disposal. Treatment amendments reduce the toxicity and mobility of the COCs by limiting bioavailability and preventing transport in both the dissolved and solid phases.
Short-Term Effectiveness	Although Alternative 1 does not create impacts, it would not achieve the RAOs. Although Alternative 2 has no construction-related impacts, it would require 10 years to achieve RAOs. Alternatives 3 and 6 would quickly achieve the RAOs, but includes high construction-related impacts. Alternative 4 would achieve RAOs in 20 years with moderate construction-related impacts.
Implementability	Alternative 1 is simple and readily implementable. Alternative 2 uses natural processes to aid remediation, thus limiting requirements for sediment removal or material placement. Alternative 3 involves removal and disposal of sediment from areas where recontamination is likely to occur if ongoing contaminant sources are not controlled prior to or during the implementation. Alternatives 4 and 6 use natural sediment remediation processes with limited material placement or sediment removal.
Cost	Estimated costs range up to $5.4 million and do not include costs for upland remediation or source control. The two major cost uncertainties are the method for dredged material disposal and the source of material for capping or ENR remediation.

Table 2-29: DU N-4 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation				Alternative 1: No Action	Alternative 2: MNR with Continued Maintenance Dredging (30 years)	Alternative 3: Dredging	Alternative 4: ENR	Alternative 6: Focused Dredging with MNR (10 years)
Threshold Criteria	*Overall Protection of Human Health and Environment*	RAO 1 (human health – seafood consumption)		RAO 1 would be achieved immediately.	RAO 1 would be achieved immediately.	RAO 1 would be achieved following construction (<1 month).	RAO 1 would be achieved immediately.	RAO 1 would be achieved following construction (<1 month).
		RAO 2 (ecological health – bottomfish)		Risks would remain elevated for approximately 30 years. No monitoring or adaptive management to ensure risk reduction.	Risks would remain elevated for approximately 30 years. Natural recovery and adaptive management would reduce risks.	RAO 2 would be achieved following construction (<1 month).	Risks would remain elevated for approximately 20 years. Natural recovery and adaptive management would reduce risks.	RAO 2 would be achieved following construction (<1 month), but designed to meet RAO in 10 years with MNR.
		RAO 3 (ecological health – waterbirds) applicable to areas less than 2 meters (6.6 feet) water depth		Not applicable to DU N-4 (small area shallower than 2 meters water depth).	Not applicable to DU N-4 (small area shallower than 2 meters water depth).	Not applicable to DU N-4 (small area shallower than 2 meters water depth).	Not applicable to DU N-4 (small area shallower than 2 meters water depth).	Not applicable to DU N-4 (small area shallower than 2 meters water depth).
		Meets Criterion?		**No.**	**Yes.**	**Yes.**	**Yes.**	**Yes.**
	Compliance with ARARs and TBCs: Meets Criterion?			**No.** No chemical-specific criteria are ARARs for Pearl Harbor sediment; however, this alternative would not achieve the chemical-specific risk-based TBC criteria developed for Pearl Harbor or comply with CERCLA requirements for protection of human health and the environment.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.
Balancing Criteria	*Long-Term Effectiveness and Permanence*	Magnitude of residual risk	Risk Remaining in Surface Sediment	Long period of elevated risks (30 years) and no ICs, monitoring, or adaptive management to further reduce risks or ensure protectiveness.	Long period of elevated risks (30 years).	Short period of elevated risk (<1 month).	Long period of elevated risks (20 years).	Short period of elevated risk (<1 month), but design is expected to have elevated risk for approximately 10 years.
			Potential risk from exposure of subsurface sediment contamination. Evaluation based on the potential impact of exposure of subsurface contamination and the chance of exposure.	Would leave a large area (2.7 acres) of subsurface sediments with COC concentrations exceeding RAL_0 in place. Potential for exposure through maintenance dredging or vessel scour is moderate.	Would leave a large area (2.7 acres) of subsurface sediments with COC concentrations exceeding RAL_0 in place. Potential for exposure through maintenance dredging or vessel scour is moderate. Monitoring and adaptive management would measure and improve long-term effectiveness.	Would not leave subsurface sediments with COC concentrations exceeding the RALs in place.	Would leave a small area (0.7 acre) of subsurface sediments with COC concentrations exceeding RAL_0 in place. Potential for exposure through maintenance dredging or vessel scour is moderate. Contamination would be left under a thin (6-inch) layer of clean material. Monitoring and adaptive management would measure and improve long-term effectiveness.	Would not leave subsurface sediments with COC concentrations exceeding the RALs in place.
		Adequacy and reliability of controls	Application of engineering and institutional controls	Would involve no engineering or institutional controls.	Would involve no ECs. Seafood consumption advisories would reduce risk, but require voluntary adherence.	Would minimize the need for engineering and institutional controls.	ENR is an engineered remedy, but less robust than capping or dredging. Therefore, reliability of ECs would be moderate. Seafood consumption advisories would reduce risk, but require voluntary adherence.	Would minimize the need for engineering and institutional controls.
		Rating:		**Poor.** Would not reduce risks to human health or the environment to acceptable levels, nor provide the ICs or contingency actions required to further reduce risks.	**Fair.** Risks would remain elevated for a significant period, and significant area or subsurface contamination with a large potential for exposure would remain on site. Monitoring and adaptive management would improve long-term effectiveness.	**Very Good.** Removal of contaminated sediment minimizes the need for monitoring, ICs, and adaptive management.	**Good.** Risks would remain elevated for a moderate period. ENR is a moderately robust engineered remedy; monitoring and adaptive management would improve permanence.	**Very Good.** Removal of contaminated sediment minimizes the need for monitoring, ICs, and adaptive management.
	Reduction of Toxicity, Mobility, or Volume through Treatment			**Poor.** Would not reduce toxicity, mobility, or volume through treatment.	**Poor.** Would not include treatment.	**Fair.** Would not include treatment unless dredged material is treated prior to disposal to reduce the toxicity, mobility, or volume of COCs.	**Poor.** Would not include treatment.	**Fair.** Would not include treatment unless dredged material is treated prior to disposal to reduce the toxicity, mobility, or volume of COCs.

Table 2-29: DU N-4 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation			Alternative 1: No Action	Alternative 2: MNR with Continued Maintenance Dredging (30 years)	Alternative 3: Dredging	Alternative 4: ENR	Alternative 6: Focused Dredging with MNR (10 years)
Balancing Criteria	*Short-Term Effective-ness*	Area or benthic habitat disturbed (dredging plus capping area) (acres)	0	0	2.7	0	2.7
		Time the water column is disturbed (construction period) (years)	0	0	<1 month	<1 month	<1 month
		CO_2/Air pollutant emissions during construction (metric tons)	0/0	0/0	200/3.5	12/0.2	190/3.4
		Worker injuries during construction	0	0	0.10	0.01	0.09
		Volume of contaminated sediment disposed of (yd^3)	0	0	13,000	0	13,000
		Volume of material placed (yd^3)	0	0	1,600	850	1,600
		Time to achieve all RAOs	May not be achieved.	RAO 1: 0 years. RAO 2: 30 years. RAO 3: not applicable.	RAO1, RAO 2, RAO 3: <1 month.	RAO 1: 0 years. RAO 2: 20 years. RAO 3: not applicable.	RAO1, RAO 2, RAO 3: <1 month.
		Rating:	**Fair.** Would create no impacts due to construction, but RAOs not achieved.	**Fair.** Would create no impacts due to construction, but long period to achieve RAOs.	**Poor.** Dredging is labor and energy intensive and disrupts the existing environment. Time achieve RAOs would be short compared to other alternatives.	**Good.** Would create low impacts due to construction, with a longer period to achieve RAOs.	**Very Good.** Rates higher than Alternatives 3 or 4 because dredging would not be required. The time required to achieve RAOs would be short compared to other alternatives.
	Implement-ability	Administrative implementability	Would likely not gain agency approval.	Would present few administrative challenges.	Would present large administrative challenges associated with disposal of dredged material, and with procurement of placement material (14,000 yd^3 total).	Would present administrative challenges associated with procurement of placement material (850 yd^3 total). Would require deed restrictions in navigational areas if ENR is implemented to ensure that the maintenance dredging depth is not increased, resulting in a breach of the remedy.	Would present large administrative challenges associated with disposal of dredged material, and with procurement of placement material (14,000 yd^3 total).
		Technical implementability (reliability of technology and recontamination potential)	Not applicable.	Would be simple to implement initially, and more challenging during monitoring and potential contingency actions. Recontamination potential would be adaptively managed over time.	Depth of contamination is approximately 3 feet, which presents few technical challenges except for management of dredge residuals. Overwater structures would present access and stability challenges. Moderate to high potential for recontamination from lateral sources. Low potential for recontamination from scour events (since the contamination has been removed).	Would be relatively simple to implement during construction, but more challenging during monitoring and potential contingency actions. Berthing areas and maintenance dredging areas may require partial dredging. Implementability challenges associated with dredging are discussed in Alternative 4. Overwater structures would present structural, access, and sediment stability challenges. Recontamination potential could be adaptively managed.	Dredging is relatively straightforward to implement, but effective residuals management would be required. This alternative would be effective to control recontamination. The potential for exposure of subsurface contamination would be managed by removing the most contaminated sediments, and adaptively managing the remaining sediments to minimize or avoid recontamination.
		Availability of services and materials	Not applicable.	Would require few services or materials.	Would present challenges with availability of materials associated with disposal of dredged material, and with procurement of placement material (14,000 yd^3 total).	Would present challenges associated with procurement of placement material (850 yd^3 total).	Would present challenges with availability of materials associated with disposal of dredged material, and with procurement of placement material (14,000 yd^3 total).
		Rating:	**Excellent.** The alternative presents no implementability challenges.	**Very Good.**	**Fair.**	**Very Good.** Relatively simple to implement initially, but potential future contingency actions could present additional challenges.	**Good.** Good balance of secondary source control of hotspot sediments and adaptive management of lower levels of contamination.
	Cost	Net present value	$0	$260,000	$5.4 million	$380,000 [a]	$3.9 million
		Rating:	**Excellent.**	**Excellent.**	**Fair.**	**Very Good.**	**Fair.**

Note: Ratings are based on a 5-tier scale: poor, fair, good, very good, excellent. Ratings were determined by comparison to other alternatives.
[a] The estimated cost of the preferred remedy (Alternative 4) was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

2.10.2.5 Comparative Analysis of Alternatives for DU E-2 (Off Waiau Power Plant)

Summary of the comparative analysis of retained remedial alternatives against the NCP nine criteria for DU E-2 (Off Waiau Power Plant) is presented in Table 2-30. The complete detailed evaluation and comparative analysis is presented in Table 2-31.

Table 2-30: DU E-2 (Off Waiau Power Plant) Summary of Comparative Analysis of Remedial Alternatives

Criterion	Considerations
Overall Protection of Human Health and the Environment	In contrast to DUs SE-1, N-2, and N-3, DU E-2 is not subject to maintenance dredging, thus improving the overall and long-term protectiveness of alternatives that incorporate natural recovery. Alternative 1 does not meet this criterion because it does not include ICs, monitoring, or contingency actions. Alternatives 8 and 9 rely on natural recovery for sediments with relatively low concentrations, and therefore, would significantly reduce COC concentrations immediately after construction is completed to achieve RAOs within a relatively short period. Alternative 7 would achieve RAOs immediately after construction.
Compliance with ARARs	Alternative 1 does not comply with ARARs because it does not include ICs, monitoring, or contingency actions to meet remediation targets. The other alternatives comply with ARARs by achieving RAOs through a combination of active remediation, OCs, natural recovery, and/or adaptive management.
Long-Term Effectiveness and Permanence	Alternatives 1 and 2 leave subsurface sediment with elevated COC concentrations in place, where it could be potentially exposed in the future, and rely heavily on seafood consumption advisories for protection of human health. Alternatives 7 and 9 leave contaminated sediment place and isolate it under engineered caps. Alternative 8 removes contaminated sediment and minimizes the need for seafood consumption advisories.
Reduction of Toxicity, Mobility, or Volume through Treatment	Alternatives 1, 2, 7, and 9 do not meet this criterion. Alternative 8 does not include treatment unless the dredged material is treated prior to disposal. Treatment amendments reduce the toxicity and mobility of the COCs by limiting bioavailability and preventing transport in both the dissolved and solid phases.
Short-Term Effectiveness	Although Alternative1 does not create impacts, it would not achieve the RAOs. Alternative 2 does not create construction-related impacts, but would require 30 years to achieve RAOs. Alternatives 8 and 9 have relatively low construction-related impacts; however, these alternatives would require 10 years to achieve RAOs. Alternative 7 would achieve RAOs after remedial construction is completed but does create moderate construction-related impacts.
Implementability	Alternative 1 is readily implementable. Alternative 2 uses natural processes to aid remediation, thus limiting requirements for sediment removal or material placement. Alternatives 7 and 9 are relatively straightforward to implement; however, the design may require armored caps due to periodic discharges from the power plant’s cooling outfall. Alternative 8 requires removal and disposal of a relatively small volume of material, with low to moderate probability of recontamination near the outfall.
Cost	Estimated costs range up to $6.2 million to complete the in-water sediment remedy, and do not include costs for upland remediation or source control. The two major cost uncertainties are the method for dredged material disposal and the source of material for capping or ENR remediation.

Table 2-31: DU E-2 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation				Alternative 1: No Action	Alternative 2: MNR (30 Years)	Alternative 7: Focused Capping with ENR	Alternative 8: Focused Dredging with MNR (10 years)	Alternative 9: Focused Capping with ENR and MNR (10 years)
Threshold Criteria	*Overall Protection of Human Health and Environment*	RAO 1 (human health – seafood consumption)		Risks would remain elevated for approximately 30 years. No ICs, monitoring, or adaptive management to further reduce risks.	With ICs (fish consumption advisories), risk reduction would be achieved immediately. Based on SWACs, risks would remain elevated for approximately 30 years. Natural recovery and adaptive management would reduce risks.	RAO 1 would be achieved following construction (<1 month).	With ICs (fish consumption advisories), risk reduction would be achieved immediately. Based on SWACs, risks would be achieved in approximately 10 years.	With ICs (fish consumption advisories), risk reduction would be achieved immediately. Based on SWACs, risks would remain elevated for approximately 10 years. Natural recovery and adaptive management would reduce risks.
		RAO 2 (ecological health – bottomfish)		Risks would remain elevated for approximately 20 years. No monitoring or adaptive management to ensure risk reduction.	Risks would remain elevated for approximately 20 years. Monitoring and adaptive management would increase risk reduction.	RAO 2 would be achieved following construction (<1 month).	RAO 2 would be achieved following construction (<1 month).	RAO 2 would be achieved following construction (<1 month).
		RAO 3 (ecological health – waterbirds) applicable to areas less than 2 meters (6.6 feet) water depth		Risks would remain elevated for approximately 30 years. No monitoring or adaptive management to ensure risk reduction.	Risks would remain elevated for approximately 30 years. Monitoring and adaptive management would increase risk reduction.	RAO 3 would be achieved following construction (<1 month).	RAO 3 would be achieved in approximately 10 years.	RAO 3 would be achieved in approximately 10 years.
		Meets Criterion?		**No.** Long period of elevated risks (30 years) and no ICs, monitoring, or adaptive management to further reduce risks or ensure protectiveness.	**Yes.** All RAOs would be achieved in approximately 30 years.	**Yes.** All RAOs would be achieved post-construction (<1 month).	**Yes.** All RAOs would be achieved in approximately 10 years.	**Yes.** Risks would remain elevated for approximately 10 years.
	Compliance with ARARs and TBCs: Meets Criterion?			**No.** No chemical-specific criteria are ARARs for Pearl Harbor sediment; however, this alternative would not achieve the chemical-specific risk-based TBC criteria developed for Pearl Harbor or comply with CERCLA requirements for protection of human health and the environment.	**Yes.** Would comply with ARARs over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment following construction. Would require measures to ensure compliance with action-specific ARARs for material placement and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for material placement and maintenance of the ICs.
	Meets Threshold Requirements?			No	Yes	Yes	Yes	Yes
Balancing Criteria	*Long-Term Effectiveness and Permanence*	Magnitude of residual risk	Risk Remaining in Surface Sediment	Long periods of elevated risks (30 years) and no ICS, monitoring, or adaptive management to further reduce risks or ensure protectiveness.	Elevated risks for approximately 30 years.	Short time with elevated risks (<1 month).	Risks elevated for approximately 10 years.	Risks would remain elevated for approximately 10 years.
			Potential risk from exposure of subsurface sediment contamination. Evaluation based on the potential impact of exposure of subsurface contamination and the chance of exposure.	Would leave a large area of subsurface sediments with PCB concentrations exceeding RAL_0 (8.7 acres). Potential for exposure is low.	Would leave a large area of subsurface sediments with PCB concentrations exceeding RAL_0 (8.7 acres). Potential for exposure is low.	Would leave a large area of subsurface sediments with PCB concentrations exceeding RAL_0 (8.7 acres). Potential for exposure is low. Engineered capping ENR layer would reduce exposure potential.	Would leave a large area (7.2 acres) of subsurface sediments with PCB concentrations exceeding RAL_0 in place. Potential for exposure is low.	Would leave a large area of subsurface sediments with PCB concentrations exceeding RAL_0 (8.7 acres). Potential for exposure through vessel scour is low. Sediments with relatively high COC concentrations would be isolated under engineered caps (3.2 acres). Moderately contaminated sediments would be treated with ENR l (1.6 acres), while sediments with lower COC concentrations would be remediated by MNR (3.9 acres). Monitoring and adaptive management would measure and improve long-term effectiveness.
		Adequacy and reliability of controls	Application of engineering and institutional controls	Would involve no engineering or institutional controls.	Would involve no ECs. Seafood consumption advisories would reduce risk, but require voluntary adherence.	The reliability of ECs would be excellent in areas of higher concentrations (capping), and good in areas of less contamination (ENR). Reliability of ICs (deed restrictions to limit future dredging) would be good.	ECs would be unnecessary in areas where sediments with high COC concentrations are removed (dredging). Although MNR would not provide a high degree of ECs adaptive management and contingency actions would be implemented to ensure that this alternative remains effective over the long-term.	The reliability of ECs would be excellent for sediments with higher COC concentrations (capping), good for sediments with moderate concentrations (ENR), and poor for sediments with low concentrations (MNR). Reliability of ICs (deed restrictions to limit future dredging) would be good.
		Rating:		**Poor.** Poor long-term effectiveness. Risks would remain elevated for a significant period, and significant area or subsurface contamination with a large potential for exposure would remain on site.	**Fair.** Risks would remain elevated for a significant period, and subsurface sediment contamination would remain on site. Monitoring and adaptive management would improve long-term effectiveness.	**Good.** Capping is an engineered remedy with a low chance of allowing contaminated sediments to be exposed in the future, thus minimizing the need for contingency actions. ENR provides less-robust ECs, but would be effective for sediments with lower levels of contamination.	**Very Good.** Risks would remain elevated for a moderate period. Dredging would completely remove contaminated sediments from the DU. MNR would not provide a high degree of EC, but would be effective for sediments with lower levels of contamination.	**Good.** Capping is an engineered remedy with a low chance of allowing contaminated sediments to be exposed in the future, thus minimizing the need for contingency actions. ENR and MNR provide less-robust ECs, but would be effective for sediments with lower levels of contamination.

Table 2-31: DU E-2 Detailed Evaluation of Response Action Alternatives

Criterion and Considerations for Evaluation			Alternative 1: No Action	Alternative 2: MNR (30 Years)	Alternative 7: Focused Capping with ENR	Alternative 8: Focused Dredging with MNR (10 years)	Alternative 9: Focused Capping with ENR and MNR (10 years)
Balancing Criteria	*Reduction of Toxicity, Mobility, or Volume through Treatment*		**Poor.** Would not reduce toxicity, mobility, or volume through treatment.	**Poor.** Would not include treatment.	**Poor.** Would not include treatment.	**Fair.** Would not include treatment unless the dredged material is treated prior to disposal to reduce the toxicity, mobility, or volume of COCs.	**Poor.** Would not include treatment.
	Short-Term Effective-ness	Area or benthic habitat disturbed (dredging plus capping area) (acres)	0	0	4.8	1.5	3.2
		Time the water column is disturbed (construction period) (years)	0	0	<1 month	<1 month	<1 month
		CO_2/Air pollutant emissions during construction (metric tons)	0/0	0/0	210/3	93/0.4	48/1
		Worker injuries during construction	0	0	0.13	0.06	0.01
		Volume of contaminated sediment disposed of (yd^3)	0	0	0	7,500	0
		Volume of material placed (yd^3)	0	0	32,000	900	20,000
		Time to achieve all RAOs	May not be achieved.	RAO 1: 30 years. RAO 2: 20 years. RAO 3: 30 years.	RAO 1, RAO 2, RAO 3: <1 month.	RAO 1: 10 years. RAO 2: 0 years. RAO 3: 10 years.	AO 1, RAO 2, RAO 3: approximately 10 years.
		Rating:	**Fair.** Would create no impacts due to construction, but RAOs may not achieved.	**Good.** Would create no impacts due to construction, but RAOs are achieved over a longer period.	**Very Good.** Would have moderate impacts during construction. Time to achieve RAOs would be short.	**Good.** Moderate impacts for construction, moderate time to achieve RAOs.	**Good.** Would have low impacts during construction. Time to achieve RAOs would be moderate.
	Implement-ability	Administrative implementability	Not likely to gain agency approval.	Would present few administrative challenges.	Would present large administrative challenges associated with procurement of placement material (32,000 yd^3 total). Would require deed restrictions in navigational areas if capped to ensure that the maintenance dredging depth is not increased, resulting in a breach of the cap.	Would present some administrative challenges associated with disposal of dredged material (7,500 yd^3 total), and with procurement of placement material (900 yd^3 total).	Would present moderate administrative challenges associated with disposal of dredged material, and with procurement of placement material (20,000 yd^3 total).
		Technical implementability (reliability of technology and recontamination potential)	Not applicable.	Would be simple to implement initially, and more challenging during monitoring and adaptive management. Recontamination potential can be adaptively managed.	Capping and ENR are relatively straightforward to implement, but design requires attention to location-specific conditions such as currents, concentrations, and groundwater flux; and cap design considerations such as material specifications, carbon or reactive material content, armoring and grain size, thickness, and placement techniques. Presence of periodic discharge of large flux of water from the power plant's cooling outfall may require armoring. Overwater structures would present structural, access, and sediment stability challenges. Recontamination potential is low to moderate and localized around a nearshore outfall. Timing of remedial action would need to be coordinated with lateral source control efforts.	Dredging is relatively straightforward to implement. Implementability of dredging is higher compared to other DUs because of the very low probability for presence of UXO in the area. Recontamination potential is low to moderate and localized around a nearshore outfall. Timing of remedial action would need to be coordinated with lateral source control efforts. MNR can adaptively manage localized recontamination.	Capping and ENR are relatively straightforward to implement, but design requires attention to location-specific conditions such as currents, concentrations, and groundwater flux; and cap design considerations such as material specifications, carbon or reactive material content, armoring and grain size, thickness, and placement techniques. Presence of periodic discharge of large flux of water from the power plant's cooling outfall may require armoring. Overwater structures would present structural, access, and sediment stability challenges. Timing of capping effort would need to be coordinated with lateral source control efforts. ENR and MNR can adaptively manage localized recontamination.
		Availability of services and materials	Not applicable.	Would require few services or materials.	Would present challenges associated with availability of materials for disposal of dredged material, and with procurement of placement material (32,000 yd^3 total).	Would present challenges associated with availability of materials for disposal of dredged material (7,500 yd^3), and with procurement of placement material (900 yd^3 total).	Would present challenges associated with availability of materials for disposal of dredged material, and with procurement of placement material (20,000 yd^3 total).
		Rating:	**Excellent.** The alternative presents no implementability challenges.	**Excellent.** Would be simple to implement initially, but potential future contingency actions would present additional challenges.	**Good.** Would be relatively easy to implement; however, armoring may be required.	**Very Good.** Would be relatively easy to implement compared to other DUs due to low potential for UXO encounter.	**Good.** Would be relatively easy to implement; however, armoring may be required.
	Cost	Net present value	$0	$580,000	$6.2 million	$3.4 million [a]	$3.9 million
		Rating:	**Excellent.**	**Excellent.**	**Good.**	**Good.**	**Good.**

Note: Ratings are based on a 5-tier scale: poor, fair, good, very good, excellent. Ratings were determined by comparison to other alternatives.
UXO unexploded ordnance
[a] The estimated cost of the preferred remedy (Alternative 8) was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

2.10.2.6 COMPARATIVE ANALYSIS OF ALTERNATIVES FOR DU E-3 (AIEA BAY)

Summary of the comparative analysis of retained remedial alternatives against the NCP nine criteria for DU E-3 (Aiea Bay) is presented in Table 2-32. The complete detailed evaluation and comparative analysis is presented in Table 2-33.

Table 2-32: DU E-3 (Aiea Bay) Summary of Comparative Analysis of Remedial Alternatives

Criterion	Considerations
Overall Protection of Human Health and the Environment	Alternative 1 does not meet this criterion because it does not include ICs, monitoring, or contingency actions. Alternative 2 relies on natural recovery but includes ICs, monitoring, and contingency actions to reduce risks and ensure that RAOs are met in the long term. Alternatives 5 and 6 reduce risk after remedial construction is completed, and isolate or treat areas with high COC concentrations.
Compliance with ARARs	Alternative 1 does not comply with ARARs because it does not include ICs, monitoring, or contingency actions to meet remediation targets. The other alternatives comply with ARARs by achieving RAOs through a combination of active remediation, ICs, natural recovery, and/or adaptive management.
Long-Term Effectiveness and Permanence	Alternatives 1 and 2 leave subsurface sediment with elevated COC concentrations in place, where it could potentially be exposed in the future, and rely heavily on seafood consumption advisories for protection of human health. Alternative 5 includes active remediation, but leaves buried contamination on site under thin layers of clean sediment and limits reliance on seafood consumption advisories. Alternative 6 isolates the contaminated sediment under engineered caps and minimizes the need for seafood consumption advisories.
Reduction of Toxicity, Mobility, or Volume through Treatment	None of the alternatives meets this criterion because they do not include treatment.
Short-Term Effectiveness	Although Alternative 1 does not create impacts, it would not achieve RAOs. Alternative 2 does not create construction-related impacts, but would require 10 years to achieve RAOs. Alternatives 5 and 6 have relatively low or moderate impacts, and RAOs would be achieved after remedial construction is completed.
Implementability	Alternative 1 is simple and readily implementable. Alternatives 2 and 5 use natural processes to aid remediation, thus limiting requirements for sediment removal or material placement. Alternative 6 is relatively straightforward to implement; however, the design requires attention to cap material specifications (carbon or reactive material content) and location-specific conditions such as currents and groundwater flux.
Cost	Estimates range up to $28 million to complete the in-water sediment remedy, and do not include costs for upland remediation or source control. The major cost uncertainty is the source of material for capping or ENR remediation.

Table 2-33: DU E-3 Detailed Evaluation of Remedial Alternatives

Criterion and Considerations for Evaluation				Alternative 1: No Action	Alternative 2: MNR (10 Years)	Alternative 5: ENR	Alternative 6: Capping
Threshold Criteria	*Overall Protection of Human Health and Environment*	RAO 1 (human health – seafood consumption)		RAO 1 would be achieved immediately.	RAO 1 would be achieved immediately.	RAO 1 would be achieved immediately.	RAO 1 would be achieved immediately.
		RAO 2 (ecological health – bottomfish)		RAO 2 would be achieved immediately.	RAO 2 would be achieved immediately.	RAO 2 would be achieved immediately.	RAO 2 would be achieved immediately.
		RAO 3 (ecological health – waterbirds) applicable to areas less than 2 meters (6.6 feet) water depth		Not applicable to DU E-3 (small area shallower than 2 meters water depth).	Not applicable to DU E-3 (small area shallower than 2 meters water depth).	Not applicable to DU E-3 (small area shallower than 2 meters water depth).	Not applicable to DU E-3 (small area shallower than 2 meters water depth).
		Meets Criterion?		**Yes.** No ICs, monitoring, or adaptive management to further reduce risks or assume protectiveness.	**Yes.** RAO 1 and RAO 2 would be achieved at year 0; RAO 3 is not applicable. However, SWACs are still above background-based PRGs.	**Yes.** RAO 1 and RAO 2 would be achieved post-construction; RAO 3 is not applicable. However, SWACs are still above background-based PRGs.	**Yes.** RAO 1 and RAO 2 would be achieved post-construction; RAO 3 is not applicable. However, SWAC is still above background-based PRGs.
	Compliance with ARARs and TBCs: Meets Criterion?			**No.** No chemical-specific criteria are ARARs for Pearl Harbor sediment; however, this alternative would not achieve the chemical-specific risk-based TBC criteria developed for Pearl Harbor or comply with CERCLA requirements for protection of human health and the environment.	**Yes.** Would comply with ARARs by protecting human health and the environment over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for dredging, dredged material disposal, material placement, and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment either immediately following construction or over time with natural recovery, ICs, monitoring, and potential contingency actions. Would require measures to ensure compliance with action-specific ARARs for material placement and maintenance of the ICs.	**Yes.** Would comply with ARARs by protecting human health and the environment following construction. Would require measures to ensure compliance with action-specific ARARs for material placement and maintenance of the ICs.
	Meets Threshold Requirements?			No	Yes	Yes	Yes
Balancing Criteria	*Long-Term Effectiveness and Permanence*	Magnitude of residual risk	Risk Remaining in Surface Sediment	Short period of elevated risks and no ICs, monitoring, or adaptive management to further reduce risks or ensure protectiveness.	Short period of elevated risks (0 years).	Short period of elevated risk.	Short period of elevated risk (1 year).
			Potential risk from exposure of subsurface sediment contamination. Evaluation based on the potential impact of exposure of subsurface contamination and the chance of exposure.	Would leave a large area of subsurface sediments with COC concentrations exceeding RAL_0 (32 acres). Potential for exposure through vessel scour or erosion is very low.	Would leave a large area of subsurface sediments with COC concentrations exceeding RAL_0 (32 acres). Potential for exposure through vessel scour or erosion is very low. Monitoring and adaptive management would measure and improve long-term effectiveness.	Would leave a moderate area of subsurface sediments with COC concentrations exceeding RAL_0 (30 acres). Potential for exposure through vessel scour is very low. Contamination would be left under a thin (6-inch) layer of clean material (30 acres). Monitoring and adaptive management would measure and improve long-term effectiveness.	Would leave a large area of subsurface sediments with COC concentrations exceeding RAL_0 (32 acres). Potential for exposure through vessel scour is very low. Contaminated areas would be under engineered caps (30 acres). Monitoring and adaptive management would measure and improve long-term effectiveness.
		Adequacy and reliability of controls	Application of engineering and institutional controls	Would involve no engineering or institutional controls.	Would involve no significant ECs.	ENR is an engineered remedy, but less robust than capping or dredging. Therefore, the reliability of ECs would be moderate. Seafood consumption advisories would reduce risk, but require voluntary adherence.	Reliability of ECs would be excellent in areas of higher concentrations (partial dredging and capping), and good in areas of less contamination (ENR). Reliability of (deed restrictions to limit future dredging) would be good. Reliance on seafood consumption advisories would be minimized.
		Rating:		**Fair.** Risk would remain with no further monitoring.	**Good.** Contaminated subsurface sediments that could be exposed in the future would remain on site. Monitoring and adaptive management would improve long-term effectiveness.	**Very Good.** Risks would remain elevated for a moderate period. ENR is a moderately robust engineered remedy. Monitoring and adaptive management would improve permanence.	**Excellent.** Capping is an engineered remedy with a low chance of allowing contaminated sediments to be exposed in the future, thus minimizing the need for contingency actions.
	Reduction of Toxicity, Mobility, or Volume through Treatment			**Poor.** Would not reduce toxicity, mobility, or volume through treatment.	**Poor.** Would not include treatment.	**Poor.** Would not include treatment.	**Poor.** Would not include treatment.
	Short-Term Effectiveness	Area or benthic habitat disturbed (dredging plus capping area) (acres)		0	0	0	30
		Time the water column is disturbed (construction period) (years)		0	0	<1 (0.4 months)	2 months
		CO_2/Air pollutant emissions during construction (metric tons)		0/0	0	240/3	1,100/15
		Worker injuries during construction		0	0	0.2	0.7
		Volume of contaminated sediment disposed of (yd^3)		0	0	0	0
		Volume of material placed (yd^3)		0	0	36,000	170,000
		Time to achieve all RAOs		RAO 1 and RAO 2: year 0. RAO 3: not applicable.	RAO 1 and RAO 2: year 0. RAO 3: not applicable.	RAO 1 and RAO 2: post-construction. RAO 3: not applicable.	RAO 1 and RAO 2: post-construction (1 year). RAO 3: not applicable.
		Rating:		**Fair.** Would create no impacts due to construction; RAOs would be achieved immediately.	**Excellent.** Would create no impacts due to construction, but may require long period to achieve RAOs.	**Good.** Minimal impacts from construction, moderate time to achieve RAOs.	**Fair.** Would create moderate impacts during construction. Time to achieve RAOs would be short.

Table 2-33: DU E-3 Detailed Evaluation of Remedial Alternatives

Criterion and Considerations for Evaluation			Alternative 1: No Action	Alternative 2: MNR (10 Years)	Alternative 5: ENR	Alternative 6: Capping
Balancing Criteria	*Implement-ability*	Administrative implementability	Not likely to gain agency approval.	Would present few administrative challenges.	Would present administrative challenges with procurement of placement material (36,000 yd^3 total).	Would present large administrative challenges associated with procurement of placement material (170,000 yd^3 total). Would require deed restrictions in navigational areas if capped to ensure that the maintenance dredging depth is not increased, resulting in a breach of the cap.
		Technical implementability (reliability of technology and recontamination potential)	No technical challenges.	Would be simple to implement initially, and more challenging during potential adaptive management if RAOs are not achieved in the long term. Recontamination potential is adaptively managed.	Would be relatively simple to implement during construction, but more challenging during monitoring repair, and adaptive management. Overwater structures would present structural, access, and sediment stability challenges. Recontamination potential is considered low for this DU (lack of much vessel traffic or lateral sources); recontamination if present would be adaptively managed.	Capping is relatively straightforward to implement, but design requires attention to location-specific conditions such as currents, concentrations, and groundwater flux; and cap design considerations such as material specifications, carbon or reactive material content, armoring and grain size, thickness, and placement techniques. Overwater structures would present structural, access, and sediment stability challenges. Low recontamination potential.
		Availability of services and materials	No challenges for availability.	Would require few services or materials.	Would present challenges associated with procurement of placement material (36,000 yd^3 total).	Would present challenges associated with procurement of placement material (170,000 yd^3 total).
		Rating:	**Excellent.** The alternative presents no implementability challenges.	**Excellent.**	**Good.** Would be relatively simple to implement initially; potential future repairs would present additional challenges.	**Fair.** Would present moderate challenges during construction.
	Cost	Net present value	$0	$2.4 million	$12 million	$28 million
		Rating:	**Excellent.**	**Very Good.**	**Good.**	**Poor.**

Note: Ratings are based on a 5-tier scale: poor, fair, good, very good, excellent. Ratings were determined by comparison to other alternatives.

2.11 PRINCIPAL THREAT WASTE

The NCP establishes an expectation that treatment will be used to address the principal threats (i.e., source material that is highly toxic and/or highly mobile) posed by a site wherever practicable. No highly toxic or highly mobile source material was identified at the Pearl Harbor Sediment site; therefore, no principal threat wastes exist.

2.12 SELECTED REMEDY

This ROD presents the selected remedial alternatives for the Pearl Harbor Sediment site in accordance with CERCLA, and to the extent practicable, the NCP. This decision is based on the information contained in the AR, which includes the public comments on the PP for the Pearl Harbor Sediment site.

The following sections present the rationale for remedy selection, description of the selected remedy, estimated remedy costs, and the expected outcomes of the remedy.

2.12.1 Summary of the Rationale for the Selected Remedy

A summary of the detailed and comparative analysis against the NCP nine criteria for each DU is presented in Table 2-34 – Table 2-39. Based on the screening of RA technologies, RA alternatives, and the evaluation and comparative analysis of retained alternatives, the selected remedies and the rationales of remedy selection for the Pearl Harbor Sediment site are as follows:

- **DU SE-1 (Southeast Loch):** *Alternative 13: Focused Dredging with ENR, AC, and MNR.* DU SE-1 has a large area of relatively low COC concentrations compared to areas of moderate to high COC concentrations. This alternative will substantially reduce COC concentrations immediately by removing sediments with high COC concentrations, enhance the rate of natural recovery of sediments with moderate COC concentrations, and reduce the remaining risk by limiting bioavailability of COCs in sediment through the use of AC amendment during the natural recovery period. This combination of technologies costs relatively less compared to the other alternatives; minimizes construction-related impacts to the environment, society, and economy) compared to other alternatives; and reduces risk to achieve the RAOs within a reasonable period (20 years) through combined active remedial technologies and natural recovery.
- **DU N-2 (Oscar 1 and 2 Piers Shoreline):** *Alternative 10: ENR with MNR.* This alternative is readily implementable to reduce risk to human health and the environment by enhancing the rate of natural recovery of sediments with moderate COC concentrations to achieve the RAOs within a relatively short period (10 years). This alternative is a sustainable, cost-effective remedy with minimal construction-related impacts to the environment.
- **DU N-3 (Off Ford Island Landfill and Camel Refurbishing Area):** *Alternative 4: ENR.* This alternative is a readily implementable, cost-effective remedy that will reduce risk to achieve the RAOs immediately following implementation, while minimizing construction-related impacts to the environment.
- **DU N-4 (Bishop Point):** *Alternative 4: ENR.* This alternative is a highly implementable, cost-effective remedy that will reduce risk and achieve the RAOs within a relatively short period (20 years) following implementation. There is minimal impact from construction to the environment from this alternative compared to the other alternatives.

- **DU E-2 (Off Waiau Power Plant):** *Alternative 8: Focused Dredging with MNR.* This alternative will substantially reduce risk to human health and the environment immediately by removing sediments with high COC concentrations. This alternative also relies on natural recovery to reduce sediment COC concentrations and achieve the RAOs within a relatively short period (10 years) following implementation, thus minimizing construction-related impacts to the environment, society, and economy.
- **DU E-3 (Aiea Bay):** *Alternative 2: MNR.* This alternative is a low-cost and highly implementable remedy with minimal impact to the environment, society, and economy because no construction-related activities are required to address the relatively low risk presented by COCs in sediments within this DU.

Although fish tissue concentration threshold is not identified as a PRG, these remedial alternatives are also projected to achieve the PCB fish tissue target concentration of 190 µg/kg ww for fish fillets within the 10- to 20-year natural recovery period following completion of remedy construction. Fish tissue monitoring will be included as part of the long-term monitoring program to evaluate remedy effectiveness.

The remedial footprint based on the selected remedy for the six DUs are presented in Figure 2-20 – Figure 2-25).

2.12.2 Description of the Selected Remedy

The elements of the selected remedy include the following:

- Implementation of the remedial action via a combination of focused dredging, ENR, AC amendment treatment, and MNR for the Pearl Harbor Sediment site (Figure 2-20 – Figure 2-25)
- Institutional controls (ICs)
- Long-term monitoring
- Periodic inspections
- Five-year reviews

As discussed in Section 2.9.1, source control is assumed to be an integral part of all remedial actions (except the No Action Alternative) to ensure that ongoing sources and pathways such as contaminated upland sites, storm water, and industrial discharges that may cause recontamination after cleanup have been addressed. Source control is assumed to be generally completed when construction begins, and source control measures are assumed to be funded by other programs or parties at no additional cost to the project. Source control strategies are presented in Section 2.9.1.

Remedial Action: The implementation of the remedial action (focused dredging, ENR, AC amendment treatment, and MNR) will protect human and ecological receptors potentially exposed to chemicals in impacted sediment. Following implementation of remedial action, additional safeguards are necessary to ensure that human health and the environment remain protected. This goal can be achieved with ICs or through contingency actions in the event that ENR and/or MNR do not achieve the RAOs within the projected time frame.

ICs: ICs are primarily legal mechanisms consisting of seafood consumption advisories and deed restrictions to prevent or limit exposure of human receptors to acceptable levels by restricting human access to the contaminated sediment, and limiting the potential for human consumption of fish, shellfish, and other aquatic organisms that may bioaccumulate the COCs. ICs are also necessary to prevent exposure of buried contamination for any remedial alternative that leaves subsurface sediment contamination in place. The Navy owns and controls access to the harbor and shoreline surrounding the DUs (except the onshore area adjacent to DU E-2); therefore, LUCs, access restrictions, and security measures are already in place. Public advisories regarding fish and shellfish consumption are currently posted along the shoreline of the DUs. The onshore area adjacent to DU E-2 is occupied by an electrical power plant owned and operated by HECO; therefore, additional IC and source control measures may be required to implement alternative for DU E-2.

Institutional controls will be maintained until the concentrations of hazardous substances in the sediment are at such levels to allow for unrestricted use and exposure.

A RA Work Plan will be prepared as the land use component of the Remedial Design. Within 90 days of ROD signature, the Navy shall prepare and submit to EPA for review and approval a RA Work Plan that shall contain implementation and maintenance actions, including periodic inspections.

Long-term Monitoring: Long-term monitoring would be performed to ensure that the remedies are functioning as anticipated. Long-term monitoring typically includes collecting and evaluating data representing sediment for an extended period following the remedial action to assess achievement of RAOs.

Five-Year Reviews: CERCLA five-year reviews (42 U.S.C. §§9601-9675) will be conducted to ensure that the IC mechanisms remain in place, and to verify that legal and physical notices of ICs are maintained until restrictions are no longer necessary to be protective. Advances in science and technology, site use exposure assumptions, relevant regulations and screening levels, and chemical toxicity values will be reviewed to ensure that that selected remedy remains protective.

IC Performance Objectives: Performance objectives for the ICs include the following:

- Prevent development of the site for any use other than commercial or industrial activities.
- Minimize or eliminate direct human contact with, or ingestion of, contaminated sediment.
- Provide adequate notice of the presence of contaminated sediment to site users, workers, and any potential landowners.
- Prevent unauthorized excavation and removal of sediment without proper handling and disposal, and prohibit any construction or development that may allow for migration or relocation of contaminated soil to areas where human or ecological exposure could occur.

The Navy is responsible for implementing, reporting on, maintaining, and enforcing the ICs.

Although the Navy may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, the Navy shall retain ultimate responsibility for remedy integrity.

2.12.3 Refined Extent of Remedy Implementation for the Selected Remedy

The Navy collected additional data in 2017 as part of the remedial BOD preparation after the completion of the PP review period and after all public comments had been addressed. The Navy obtained the regulatory agencies' agreement to collect the data needed for the design given that the preferred remedial alternatives presented in the PP had achieved both regulatory and community acceptance as the selected remedy. The BOD data was collected as part of the remedial design process to refine the extent of remedy implementation for the selected remedial alternatives. The 2017 BOD investigation results were combined with the previously described results from the FS and used to refine the extent of sediments that will require remedial action within the established remedy footprint to achieve the RAOs (Section 2.8). Previous estimated costs developed in the FS assumed that the remedy assigned to a DU sub-area identified for that remedy will be implemented over the entire remediation footprint identified in the FS. However, additional data from the 2017 BOD field investigation indicate that implementation of the pre-designed remedy will only be required for a portion of the remediation footprint. Following consultation with EPA and DOH, it was agreed that the appropriate approach is to include the refined extent of remedy implementation for the selected remedial alternatives into the ROD to provide the most accurate and up-to-date remediation costs. The Navy also agreed to implement MNR in the remnant areas within the remediation footprint that no longer require active remediation. Although currently designated for MNR, treatment of these remnant areas may change in the future to active remediation, if warranted, based on additional data and information in the remedial design stage.

The following is a summary of the refined implementation area within the DU:

- **DU SE-1 (Southeast Loch) – Alternative 13 (Focused Dredging with ENR, AC, and MNR [achieve PRGs in 20 years]):**
  - Area and volume of sediment for dredging revised from 5 acres and 24,000 yd^3 to 2 acres and 17,000 yd^3.
  - ENR area revised from 32 acres to 12.6 acres.
  - AC amendment area revised from 34 acres to 11 acres.
  - MNR will be implemented in the remnant areas (45.4 acres) within the active remediation footprint (dredging, ENR, and AC treatment) no longer included in the remedy implementation area. Total MNR area is therefore revised from 113 acres to 139 acres.
- **DU N-2 (Oscar 1 and 2 Piers Shoreline) – Alternative 10 (ENR and MNR [achieve PRGs in 10 years]):**
  - ENR area revised from 3.3 acres to 1.6 acres.
  - MNR will be implemented in the remnant areas (1.7 acres) within the dredging remediation footprint that is no longer included in the dredging implementation area. MNR area revised from 12.6 acres to 14.2 acres.
- **DU N-4 (Bishop Point) – Alternative 4 (ENR):**
  - ENR area revised from 3.3 acres to 0.7 acre.
  - MNR will be implemented in the remnant areas within the ENR remediation footprint (1.5 acres).

- **DU E-2 (Off Waiau Power Plant) – Alternative 8 (Focused Dredging with MNR [Achieve PRGs in 10 Years]):**
  - Area and volume of sediment for dredging revised from 4.8 acres and 12,000 yd^3 to 1.5 acres and 7,500 yd^3.
  - MNR will be implemented in the remnant areas (3.3 acres) within the dredging remediation footprint that is no longer included in the dredging implementation area. Total MNR area for the DU is therefore revised from 3.9 acres to 7.2 acres.

Details on the development of the refined remedy implementation area are presented in Attachment F. The refined remedy implementation area is presented in Figure 2-26 – Figure 2-30. The BOD investigation results indicated that no revisions were required for the areas identified for active remediation in DUs N-3 and E-3 (as described in the FS).

2.12.4 Cost Estimate for the Selected Remedy

The estimated costs for the selected remedy are based on the best available information regarding the anticipated scope of the remedial alternative action as described in the FS (DON 2015) and PP (DON 2016). The estimated costs of the selected remedy were updated based on the new data and information provided by the 2017 BOD investigation to provide the most accurate and up-to-date remediation costs as discussed in Section 2.12.3.

The total estimated cost for the selected remedy is $39,750,000 NPV (see Table 2-40). Additional changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Changes may be documented in the form of a memorandum in the AR file, an Explanation of Significant Differences, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost.

2.12.5 Expected Outcome of the Selected Remedy

The selected remedy for the Pearl Harbor Sediment site will reduce human health and ecological risks associated with contaminated sediment by reducing COC concentrations in surface sediments to protective levels. The COC cleanup levels for each DU are presented in Table 2-41. Site use will remain restricted to commercial/industrial use only. LUCs will restrict site use to commercial/industrial and will prohibit the development and use of the property for elementary and secondary schools, child care facilities, and playgrounds. The remedy does not change the current or planned future land or groundwater use. The remedy includes a component (AC amendment) which reduces the toxicity or volume of waste or contaminants through treatment at the site. However, ICs are required to be implemented because site conditions will not be compatible with unlimited land use or unrestricted exposure.

Table 2-34: DU SE-1 Comparative Analysis of Alternatives

Remedial Alternative	CERCLA Criterion								Overall Rating
	Threshold		Balancing						
	Overall Protection of Human Health and Environment	Compliance with ARARs and TBCs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost (NPV) [a]		
1: No Action	Fail	Fail	●	●	◒	⊙	⊙	$0	◒
2: MNR with Continued Maintenance Dredging (30 years)	Pass	Pass	◒	●	○	⊙	⊙	$10 million	○
3: Dredging	Pass	Pass	⊙	◒	◒	◒	●	$470 million	◒
5: ENR	Pass	Pass	○	●	○	⊖	○	$76 million	○
8: Focused Capping and Partial Dredging with ENR	Pass	Pass	⊖	◒	○	○	◒	$210 million	○
10: Focused Capping and Partial Dredging with ENR and MNR (10 years)	Pass	Pass	⊖	◒	○	○	◒	$140 million	○
12: Focused Capping and Partial Dredging with ENR, AC, and MNR (20 years)	Pass	Pass	⊖	○	○	○	⊖	$49 million	○
13: Focused Dredging with ENR, AC, and MNR (20 years)	Pass	Pass	⊖	○	○	⊖	⊖	$31.4 million [b]	⊖

Note: Ratings are compiled from DU SE-1 detailed analysis of alternatives in the FS (DON 2015).

●: poor ◒: fair ○: good ⊖: very good ⊙: excellent

[a] Low costs are given a high rating, and high costs are given a low rating.

[b] The estimated cost of the preferred remedy (Alternative 13) was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

Table 2-35: DU N-2 Comparative Analysis of Alternatives

	CERCLA Criterion								
	Threshold		Balancing						
Remedial Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs and TBCs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost (NPV) [a]		Overall Rating
1: No Action	Fail	Fail	●	●	◒	⊙	⊙	$0	◒
2: MNR with Continued Maintenance Dredging (20 Years)	Pass	Pass	◒	●	◒	⊙	⊙	$1.0 million	◒
3: Dredging	Pass	Pass	◒	◒	●	●	●	$60 million	●
8: Focused Dredging with MNR (10 Years)	Pass	Pass	⊖	◒	◒	⊖	○	$13 million	○
10: ENR with MNR (10 years)	Pass	Pass	⊖	●	⊖	⊖	⊙	$1.9 million [b]	⊖

Note: Ratings are compiled from DU N-2 detailed analysis of alternatives in the FS (DON 2015).

●: poor ◒: fair ○: good ⊖: very good ⊙: excellent

[a] Low costs are given a high rating, and high costs are given a low rating.

[b] The estimated cost of the preferred remedy (Alternative 10) was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

Table 2-36: DU N-3 Comparative Analysis of Alternatives

	CERCLA Criterion								
	Threshold		Balancing						
Remedial Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs and TBCs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost (NPV) [a]		Overall Rating
1: No Action	Fail	Fail	●	●	◒	⊙	⊙	$0	◒
2: MNR (10 Years)	Pass	Pass	◒	●	○	⊙	⊙	$180,000	○
3: Dredging	Pass	Pass	⊙	◒	◒	◒	◒	$650,000	◒
4: ENR	Pass	Pass	⊖	●	⊖	⊖	⊖	$270,000	⊖
5: Capping	Pass	Pass	⊖	●	◒	◒	○	$580,000	◒

Note: Ratings are compiled from DU N-3 detailed analysis of alternatives in the FS (DON 2015).

●: poor ◒: fair ○: good ⊖: very good ⊙: excellent

[a] Low costs are given a high rating, and high costs are given a low rating.

Table 2-37: DU N-4 Comparative Analysis of Alternatives

Remedial Alternative	CERCLA Criterion								Overall Rating
	Threshold		Balancing						
	Overall Protection of Human Health and Environment	Compliance with ARARs and TBCs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost (NPV) [a]		
1: No Action	Fail	Fail	●	●	◒	⊙	⊙	$0	◒
2: MNR with Continued Maintenance Dredging (30 years)	Pass	Pass	◒	●	◒	⊖	⊙	$260,000	◒
3: Dredging	Pass	Pass	⊖	◒	●	◒	◒	$5.4 million	◒
4: ENR	Pass	Pass	○	●	○	⊖	⊖	$380,000 [b]	⊖
6: Focused Dredging with MNR (10 years)	Pass	Pass	⊖	◒	⊖	○	◒	$3.9 million	○

Note: Ratings are compiled from DU N-4 detailed analysis of alternatives in the FS (DON 2015).

●: poor ◒: fair ○: good ⊖: very good ⊙: excellent

[a] Low costs are given a high rating, and high costs are given a low rating.

[b] The estimated cost of the preferred remedy (Alternative 4) was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

Table 2-38: DU E-2 Comparative Analysis of Alternatives

Remedial Alternative	CERCLA Criterion								Overall Rating
	Threshold		Balancing						
	Overall Protection of Human Health and Environment	Compliance with ARARs and TBCs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost (NPV) [a]		
1: No Action	Fail	Fail	●	●	◒	⊙	⊙	$0	◒
2: MNR (30 years)	Pass	Pass	◒	●	○	⊙	⊙	$580,000	○
7: Focused Capping with ENR	Pass	Pass	○	●	⊖	○	○	$6.2 million	○
8: Focused Dredging with MNR (10 years)	Pass	Pass	⊖	◒	○	⊖	○	$3.4 million [b]	⊖
9: Focused Capping with ENR and MNR (10 years)	Pass	Pass	○	●	○	○	○	$3.9 million	○

Note: Ratings are compiled from DU E-2 detailed analysis of alternatives in the FS (DON 2015).

●: poor ◒: fair ○: good ⊖: very good ⊙: excellent

[a] Low costs are given a high rating, and high costs are given a low rating.

[b] The estimated cost of the preferred remedy (Alternative 8) was updated based on the new data and information provided by the Navy's 2017 BOD investigation.

Table 2-39: DU E-3 Comparative Analysis of Alternatives

	CERCLA Criterion								
	Threshold		Balancing						
Remedial Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs and TBCs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost (NPV) [a]		Overall Rating
1: No Action	Pass	Fail	fair	poor	fair	excellent	excellent	$0	fair
2: MNR (10 Years)	Pass	Pass	good	poor	excellent	excellent	very good	$2.4 million	very good
5: ENR	Pass	Pass	very good	poor	good	good	good	$12 million	good
6: Capping	Pass	Pass	excellent	poor	fair	fair	poor	$28 million	fair

Note: Ratings are compiled from DU E-3 detailed analysis of alternatives in the FS (DON 2015).
: poor : fair : good : very good : excellent
[a] Low costs are given a high rating, and high costs are given a low rating.

Table 2-40: Cost Estimate Summary

		SE-1 (Southeast Loch): Focused Dredging with ENR, AC, and MNR (20 Years)	N-2 (Oscar 1 and 2 Piers Shoreline): ENR with MNR (10 Years)	N-3 (Off Ford Island Landfill): ENR	N-4 (Bishop Point): ENR	E-2 (Off Waiau Power Plant): Focused Dredging with MNR (10 Years)	E-3 Alt 2: MNR (10 Years)
Preconstruction							
○	Mobilization, Demobilization, and Site Restoration (project - included with DU SE-1 only)	**$1,540,000**	—	—	—	—	—
Project Management (Contractor)							
○	Labor and Supervision	$474,649	$41,532	$737	$860	$16,473	$0
○	Construction Office and Operating Expense	$165,362	$14,469	$257	$299	$5,739	$0
	Subtotal:	**$640,011**	**$56,001**	**$993**	**$1,159**	**$22,212**	**$0**
Dredging							
○	Total Dredge Area (acre)	2.0	0	0	0	1.5	0
○	Total Dredge Volume (cubic yard)	17,000	0	0	0	7,500	0
○	Labor & Equipment	$600,295	$0	$0	$0	$265,031	$0
○	**Sediment Handling and Disposal**						
	- Gravity Dewatering (on the barge)	$169,875	$0	$0	$0	$75,000	$0
	- Water Management	$214,391	$0	$0	$0	$94,654	$0
	- Disposal (non-RCRA): Transload, Transportation, Tipping	$2,830,526	$0	$0	$0	$1,249,680	$0
	- Disposal (RCRA): Transload, Transportation, and Tipping	$54,000	$0	$0	$0	$0	$0
	Subtotal:	**$3,268,792**	**$0.00**	**$0.00**	**$0.00**	**$1,419,334**	**$0.00**
○	**Dredge Residuals Placement**						
	- Material Procurement and Delivery (sand)	$100,823	$0	$0	$0	$75,368	$0
	- Labor and Equipment Cost per Day (assume 1 operation)	$21,144	$0	$0	$0	$15,805	$0
	Subtotal:	**$121,967**	**$0**	**$0**	**$0**	**$91,173**	**$0**
	Dredging Construction Subtotal:	**$3,991,054**	**$0**	**$0**	**$0**	**$1,775,538**	**$0**
Enhanced Natural Recovery (ENR)							
○	Total ENR Area (acre)	12.6	1.6	0.6	0.7	0	0
○	Total Placement Volume, Material Procurement, and Delivery (sand)	15,246	1,936	726	847	0	0
○	Material (sand) Procurement and Delivery	$2,376,089	$301,726	$113,147	$132,005	$0	$0
○	Labor and Equipment	$263,772	$33,495	$12,561	$14,654	$0	$0
	ENR Construction Subtotal:	**$2,639,861**	**$335,220**	**$125,708**	**$146,659**	**$0**	**$0**
Overwater AC Amendment Treatment							
○	Total Treatment Area (acre)	11	0	0	0	0	0
○	AC Material Procurement and Delivery (includes labor and equipment)	$1,576,200	$0	$0	$0	$0	$0
	Overwater AC Treatment Construction Subtotal:	**$1,576,200**	**$0**	**$0**	**$0**	**$0**	**$0**
Under-pier AC Amendment Treatment							
○	Total Treatment Area (acre)	8	0.7	0	0	0	0
○	AC Material Procurement and Delivery (includes labor and equipment)	$4,000,000	$350,000	$0	$0	$0	$0
	Under-pier AC Treatment Construction Subtotal:	**$4,000,000**	**$350,000**	**$0**	**$0**	**$0**	**$0**
Construction and Performance QA/QC							
○	No. Total Construction Days	50	0	0	0	11	0
○	Construction QA/QC Monitoring Subtotal	**$173,544**	**$0**	**$0**	**$0**	**$36,927**	**$0**
○	**Post-Construction Performance Monitoring**						
	- Compliance Testing (Dredging)	$21,349	$0	$0	$0	$17,460	$0
	- Compliance Testing (ENR)	$80,493	$18,169	$9,361	$10,374	$0	$0
	Subtotal:	**$275,386**	**$18,169**	**$9,361**	**$10,374**	**$54,386**	**$0**
Capital Cost (Base)		**$14,662,511**	**$759,390**	**$136,062**	**$158,192**	**$1,852,137**	**$0**
Capital Cost (Present Value)		**$14,662,511**	**$759,390**	**$136,062**	**$158,192**	**$1,852,137**	**$0**
Management, Design, and Contingency, and Other General Assumptions							
○	Project Management	$879,751	$45,563	$8,164	$9,492	$111,128	$0
○	Remedial Design	$1,759,501	$91,127	$16,327	$18,983	$222,256	$0
○	Construction Management	$1,173,001	$60,751	$10,885	$12,655	$148,171	$0
○	Scope Contingency	$2,932,502	$151,878	$27,212	$31,638	$370,427	$0
○	Bid Contingency	$2,199,377	$113,909	$20,409	$23,729	$277,820	$0
○	Sales Tax	$586,500	$30,376	$5,442	$6,328	$74,085	$0
	Subtotal:	**$9,530,632**	**$493,604**	**$88,441**	**$102,825**	**$1,203,889**	**$0**
Total Capital Cost (Including Sum of Above)		**$24,193,144**	**$1,252,994**	**$224,503**	**$261,016**	**$3,056,025**	**$0**
Performance Monitoring and Remedial Goal Monitoring (present value)							
○	Performance Monitoring (Dredging)	$34,757	$0	$0	$0	$28,755	$0
○	Performance Monitoring and Maintenance (ENR)	$364,280	$67,277	$31,967	$35,846	$0	$0
○	Performance Monitoring (MNR)	$1,686,728	$148,893	$0	$29,357	$89,507	$549,850
○	Contingency Remediation (MNR and ENR)	$3,841,091	$400,325	$15,202	$55,741	$182,426	$1,862,270
○	Remedial Goal Monitoring (project - included with DU SE-1 only)	$797,864	—	—	—	—	—
○	Institutional Controls (project - included with DU SE-1 only)	$439,880	—	—	—	—	—
	Subtotal:	**$7,164,600**	**$616,495**	**$47,169**	**$120,945**	**$300,688**	**$2,412,121**
	TOTAL REMEDY COST	**$31,400,000**	**$1,900,000**	**$270,000**	**$380,000**	**$3,400,000**	**$2,400,000**

Note: Refer to Attachment E.

Table 2-41: Summary of COC Cleanup Levels

DU	COC	Cleanup Level (PRG)	Basis for Cleanup Level
SE-1 (Southeast Loch)	Copper (mg/kg)	214	Upper-bound Background Concentration [c]
	Lead (mg/kg)	119	
	Mercury (mg/kg)	0.71	
	Total PCBs (µg/kg)	170 [a]	DOH (2012) Fish Consumption Advisory
N-2 (Oscar 1 and 2 Piers Shoreline)	Cadmium (mg/kg)	3.2	Upper-bound Background Concentration [c]
	Copper (mg/kg)	214	
	Lead (mg/kg)	119	
	Mercury (mg/kg)	0.71	
	Zn (mg/kg)	330	
	Total PCBs (µg/kg)	170 [a]	DOH (2012) Fish Consumption Advisory
N-3 (Off Ford Island Landfill and Camel Refurbishing Area)	Total PCBs (µg/kg)	170 [a]	DOH (2012) Fish Consumption Advisory
N-4 (Bishop Point)	Antimony (mg/kg)	8.4	Upper-bound Background Concentration [c]
	Lead (mg/kg)	119	
	Mercury (mg/kg)	0.71	
	Zinc (mg/kg)	330	
E-2 (Off Waiau Power Plant)	Total PCBs (µg/kg)	110 [b]	Ecological Risk-based Threshold [d, e]
E-3 (Aiea Bay)	Lead (mg/kg)	119	Upper-bound Background Concentration [c]
	Mercury (mg/kg)	0.71	
	Zn (mg/kg)	330	

COC chemical of concern
DU decision unit
LOAEL lowest-observed-adverse-effect level
PRG preliminary remediation goal
[a] Water depth 2 meters (6.6 feet) or greater.
[b] Water depth less than 2 meters (6.6 feet).
[c] From Pearl Harbor Sediment Environmental Background Analysis (DON 2006).
[d] Shallow-water ecological risk–based criterion from the RI Addendum report (DON 2013); based on the toxicity reference value of 0.11 mg/kg-day from the BERA (derived using the "Rule of 5" intermediate value between the NOAEL and LOAEL) for birds, and assuming average organic carbon in sediment, and average moisture content and lipid content in fish, using the exposure assumptions developed for the BERA (DON 2007a, Appendix M).
[e] Updated criteria based on 2009 data for total PCBs (Final RI Addendum report Appendix D.1 [DON 2013]). Water depth less than 2 meters (6.6 feet).

2.13 Statutory Determinations

Under CERCLA and the NCP, the lead agency must select a remedy that is protective of human health and the environment, comply with ARARs, is cost-effective, and utilizes permanent solutions to the maximum extent practicable. The following sections discuss how the selected remedy meets these statutory requirements.

2.13.1 Protection of Human Health and the Environment

The selected remedy for the Pearl Harbor Sediment site is protective of human health and the environment, complies with all ARARs, is cost-effective, and uses permanent solutions and alternative technologies to the maximum extent practicable. The selected remedy is anticipated to achieve all three RAOs harbor-wide within the 10- to 20-year natural recovery period following completion of remedial construction, based on projected SWACs. RAO 3 is not applicable to DUs SE-1, N-2, N-3, and N-4 due to deep water conditions (i.e., water depth greater than 6 feet). Although there is no PRG for fish tissue, the remedy is also projected to achieve the PCB fish tissue target concentration of 190 µg/kg ww for fish fillet within the 10- to 20-year natural recovery period following implementation. The selected remedy will not pose unacceptable short-term risks or cross media impacts.

2.13.2 Compliance with Applicable or Relevant and Appropriate Requirements

Detailed discussions of the ARARs and TBC criteria that were considered to evaluate the response action alternatives and select the remedy are presented in the FS (DON 2015). Table 2-42 summarizes the ARARs and TBC criteria relevant to the selected remedy for the Pearl Harbor Sediment site.

No promulgated federal or State of Hawaii criteria establish numerical standards that would be chemical-specific ARARs for Pearl Harbor sediment. However, Hawaii Advisory Tissue Levels for Edible Fish have been identified as risk-based human health criteria for the project based on DOH (2012) protocol, and have been used as TBC criteria to develop sediment PRGs and RALs for protection of human health for PCBs. PRGs selected for metals are based on site-specific background concentration.

Table 2-42: Summary of ARAR and TBC Criteria

Policy/Regulation	Issues and Requirements	Status	Requirement/Description
Chemical-Specific ARARs			
Hawaii Advisory Tissue Levels for Edible Fish (DOH 2012)	State of Hawaii's PCBs fish advisory thresholds for fish consumption in Hawaii waters.	TBC	To be considered chemical-specific criteria used to develop the remediation goal for PCBs in sediment for limited consumption of fish in Pearl Harbor.
Location-Specific ARARs			
National Coastal Zone Management Act 16 U.S.C. §1451– 1464 15 CFR §930	Conduct activities within the coastal zones in a manner consistent with approved state management programs.	Relevant and Appropriate	The CZMA specifically excludes federal lands from coastal zone (16 U.S.C. §1453[1]1). Substantive provisions may be relevant and appropriate because state coastal zone management program is developed under state law guided by the CZMA and its accompanying implementing regulations in 15 CFR §930, which require federal actions to be consistent with the State's federally approved coastal management program.
Hawaii Coastal Zone Management Law HRS Chapter 205A Section 307(c)(1) of the CZMA, 16 U.S.C. §1455 15 CFR §930	Requires federal agencies to construct or support activities that may directly affect coastal zone in a manner that is consistent with approved state coastal zone management programs. CERCLA onsite actions are not subject to administrative review; however, the lead agency is required to ensure that remedial actions comply with the substantive requirements of the state's coastal zone management plan.	Applicable	The substantive provisions of the state's regulation are applicable. The Navy will consult Hawaii coastal zone management agencies to confirm that remedial actions are consistent with substantive HCZMP requirements.
Protection of Wetlands (Executive Order 11990)	Requires federal agencies to take action to avoid adversely impacting wetlands to the extent practicable.	Applicable	Substantive provisions of the executive orders are potentially applicable; remedial actions at the site are not expected to adversely impact existing wetlands.

Policy/Regulation	Issues and Requirements	Status	Requirement/Description
National Historic Preservation Act (36 CFR Part 800) 54 U.S.C. §306108	Requires preservation of historic properties, and planning actions to minimize harm to National Historic Monuments. Federal Agencies must identify and assess the effect of federal undertakings on any historic property.	Applicable	National Historic Monuments within Pearl Harbor are potentially applicable; remedial actions are not expected to adversely impact listed historic properties located within the Harbor.
Endangered Species Act of 1973 16 U.S.C. §1536[a]	Requires conservation of threatened and endangered plants and animals and the habitats in which they are found.	Applicable	Potentially applicable; remedial actions are not expected to adversely impact threatened and endangered species.
Hawaii Endangered and Threatened Species Regulations HAR 13 Part II 122, 124	Prohibits any taking, transport, or commerce in designated species, and outlines conservation programs that mandate continued research on listed species.	Applicable	The substantive provisions of the cited regulations are applicable.
Migratory Bird Treaty Act of 1918 16 U.S.C. §703–712	Prohibits the taking of migratory birds.	Applicable	Applicable to birds listed under the act.
Action-Specific ARARs			
Clean Water Act 33 U.S.C. 1313, 1314 Most recent 304(a) list, as updated up to issuance of the ROD	Under Section 304(a), minimum criteria are developed for water quality programs established by states. Two kinds of water quality criteria are developed: one for protection of human health, and one for protection of aquatic life.	Relevant and Appropriate	Relevant and appropriate to mitigate short-term impacts to surface water from remedial action implementation and discharge to navigable water.
Clean Water Act Section 401 33 U.S.C. §1341	Any federally authorized activity that may result in any discharge into navigable waters requires reasonable assurance that the action will comply with applicable provisions of Sections 1311, 1312, 1313, 1316, and 1317 of the CWA.	Applicable	Substantive requirements are applicable for any remedial action with potential for discharge into the harbor.
Clean Water Act Section 402 33 U.S.C. §1342	Regulates discharges of pollutants from point sources to waters of the United States, and requires compliance with the standards, limitations, and regulations promulgated per Sections 301, 304, 306, 307, 308 of the CWA.	Applicable	Applicable for remedial action with potential discharge of pollutants from point sources into the harbor.
Clean Water Act Section 404 and Section 404(b)(1) Guidelines 33 U.S.C. §1344 40 CFR Part 230	Regulates discharge of dredged and fill material into navigable waters of the United States.	Applicable	Applicable to dredging, capping, ENR remedial alternatives, and designation, construction and disposal in CAD sites.
Toxic Substances Control Act 15 U.S.C. §2601 et seq.	Requires disposal of materials with PCB concentrations above 50 mg/kg to be taken off site and disposed of in a landfill permitted under Section 3004 of RCRA (Title C landfill) or a permitted PCB disposal facility.	Applicable	Applicable for removal action and disposal of dredged sediments with concentrations above 50 mg/kg. Limited amount of sediments to be removed are expected to have concentrations above 50 mg/kg.
RCRA Non-Hazardous Waste – Disposal 40 CFR §257.1 – 257.5 40 CFR Part 258	Requires that RCRA non-hazardous waste generated during investigation and remedial activities must be disposed of in an approved Subtitle D landfill.	Applicable	Applicable for upland or in-water disposal of dredged material.

Policy/Regulation	Issues and Requirements	Status	Requirement/Description
RCRA Hazardous Land Disposal – Subtitle C 40 CFR Part 261 40 CFR §264.552 and 264.554 40 CFR Part 268	Establishes requirements that regulate the classification, management, and disposal of hazardous waste as defined in 40 CFR 261. 40 CFR 264.552 and .554 specify design and operation requirements for onsite temporary storage units containing hazardous IDW. 40 CFR 268 specifies land disposal restrictions and treatment standards that apply to hazardous wastes shipped offsite for treatment and disposal.	Applicable	Applicable for characterizing wastes generated from remedial actions and designated for offsite or upland disposal; potentially relevant and appropriate for use in identifying acceptance criteria for disposal of dredged material in a CAD.
RCRA Hazardous Waste Determination 40 CFR §262.11 40 CFR §264.13(a) and (b)	Requires generators of solid waste to determine whether their waste is regulated as hazardous waste under RCRA, according to 40 CFR 261. 40 CFR 264.13 (a) and (b) specify the requirements for analyzing waste for determining whether waste is hazardous.	Applicable	Applicable for remedial action that generates hazardous waste. The determination whether wastes generated during remedial activities are hazardous will be made at the time the wastes are generated.
River and Harbors Act Section 10 33 USC §403 33 CFR parts 320–323	Prohibition of the obstruction or alteration of navigable waters of the United States; regulation of structures or work in, above, or under navigable waters.	Applicable	The substantive provisions of this requirement are applicable requirements for dredging, capping, and ENR construction that may affect navigable waters within the harbor.
Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA) or Ocean Dumping Act 33 U.S.C. §1401–1445	Regulates disposal of dredge material in the ocean.	Applicable	Substantive provisions are applicable if dredged material from remedial action is disposed of in the ocean.
Air Pollution Control Standards (HAR 11-60) (DOH 2009)	Requires controls for air pollution caused by fugitive dust.	Applicable	Applicable to remedial actions that include activities potentially generating dust.

CAD confined aquatic disposal
CWA Clean Water Act
CZMA Coastal Zone Management Act
HCZMP Hawaii Coastal Zone Management Program
HRS Hawaii Revised Statutes
IDW investigation-derived waste
U.S.C. United States Code

2.13.3 Cost-Effectiveness

The selected remedy is cost-effective and represents a reasonable value for the expended public funding. The FS (DON 2015) evaluated and compared the cost-effectiveness of each RA alternative by comparing the cost of the alternative to its overall ability to protect human health and the environment (i.e., overall effectiveness). The cost-effectiveness comparisons are presented in Table 2-34 to Table 2-39. The overall effectiveness of each alternative was quantified by evaluating its performance with respect to three of the five primary balancing criteria: long-term effectiveness and permanence, reduction in toxicity, mobility, and volume through treatment, and short-term effectiveness. The selected remedy is effective in meeting RAOs and protecting human health and the environment, is implementable, and is cost-effective.

2.13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner. Specifically, the combination of focused dredging, ENR, AC amendment treatment, and MNR provides the best short- and long-term effectiveness, is protective of human health and the environment, complies with ARARs, achieves response action objectives, reduces contaminant mobility, and is technically feasible. Details of the response action alternative evaluation are presented in the FS (DON 2015).

2.13.5 Preference for Treatment as a Principal Element

This selected remedy does not satisfy the statutory preference for treatment as a principal element of the remedy. The NCP (40 CFR §300.430[a][1][iii][A]) establishes the expectation that treatment will be used to address the principal threats at a site where practicable. A principal threat waste is source material with toxicity and mobility characteristics that combine to pose a potential risk greater than the risk level that is acceptable for the current or future exposure scenarios. There are no principal threat wastes at the Pearl Harbor Sediment site. Because there are no principal threat wastes, treatment is not necessary as a principal element of the selected remedy for the Pearl Harbor Sediment site.

2.13.6 Five-Year Review Requirement

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

The PP identified a combination of focused dredging, ENR, AC amendment treatment, and MNR as the selected remedy for the Pearl Harbor Sediment site. The PP was released for public comment on February 1, 2016, and a public meeting to present and discuss the PP was held on February 10, 2016. The public comment period for the PP was initially held between February 1, 2016 and March 1, 2016 and later extended to April 1, 2016. None of the comments affect the preference for the selected remedy. Refinement of the remedy implementation area based on additional BOD data collected in 2017 resulted only in the extent and cost parameters, with no changes to the components of the selected remedial alternatives. Therefore, no significant changes to the selected remedy, as originally identified in the PP, were necessary or appropriate.

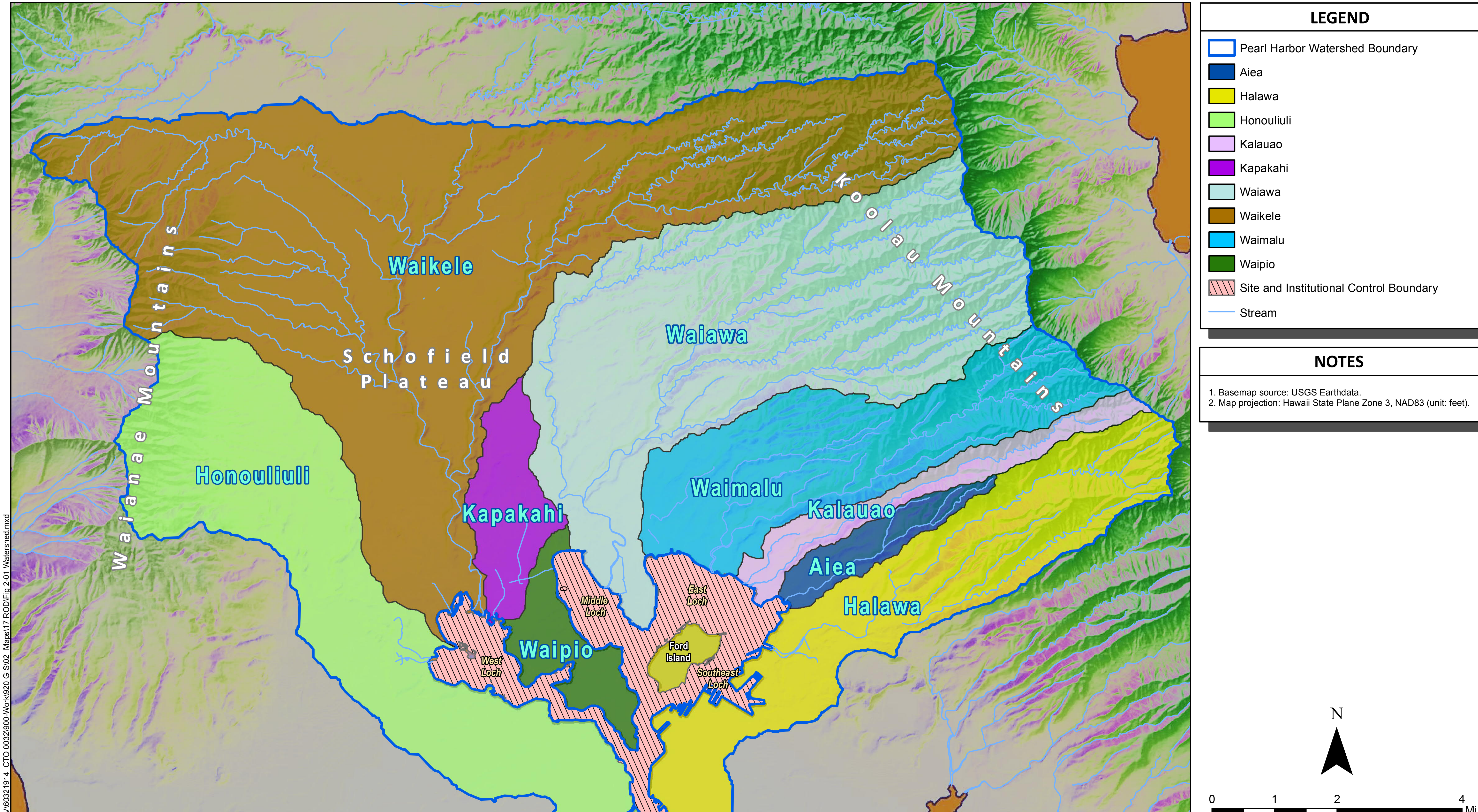

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Figure 2-1
Sub-Watersheds
within the Pearl Harbor Watershed
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

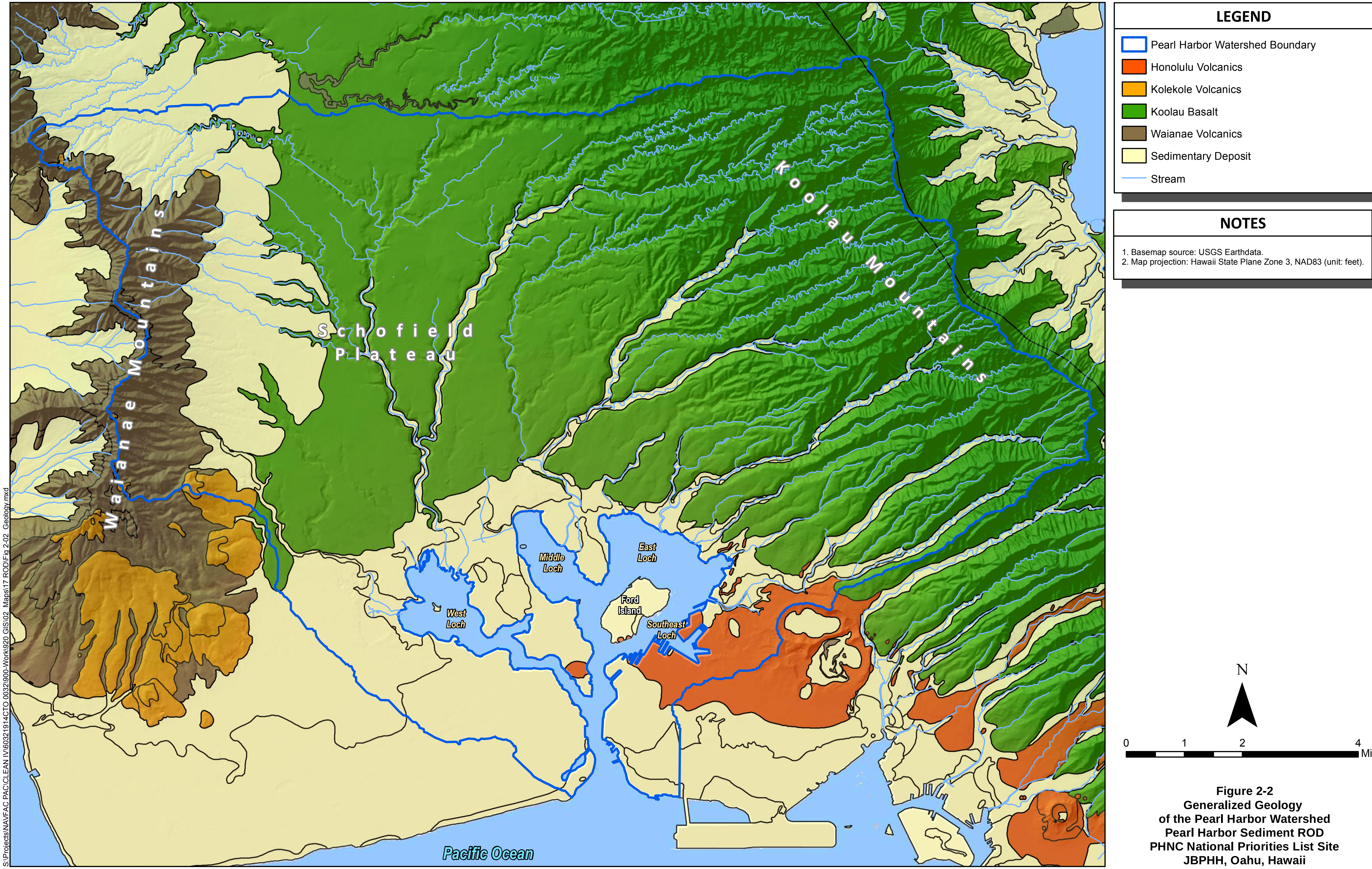

Figure 2-2
Generalized Geology
of the Pearl Harbor Watershed
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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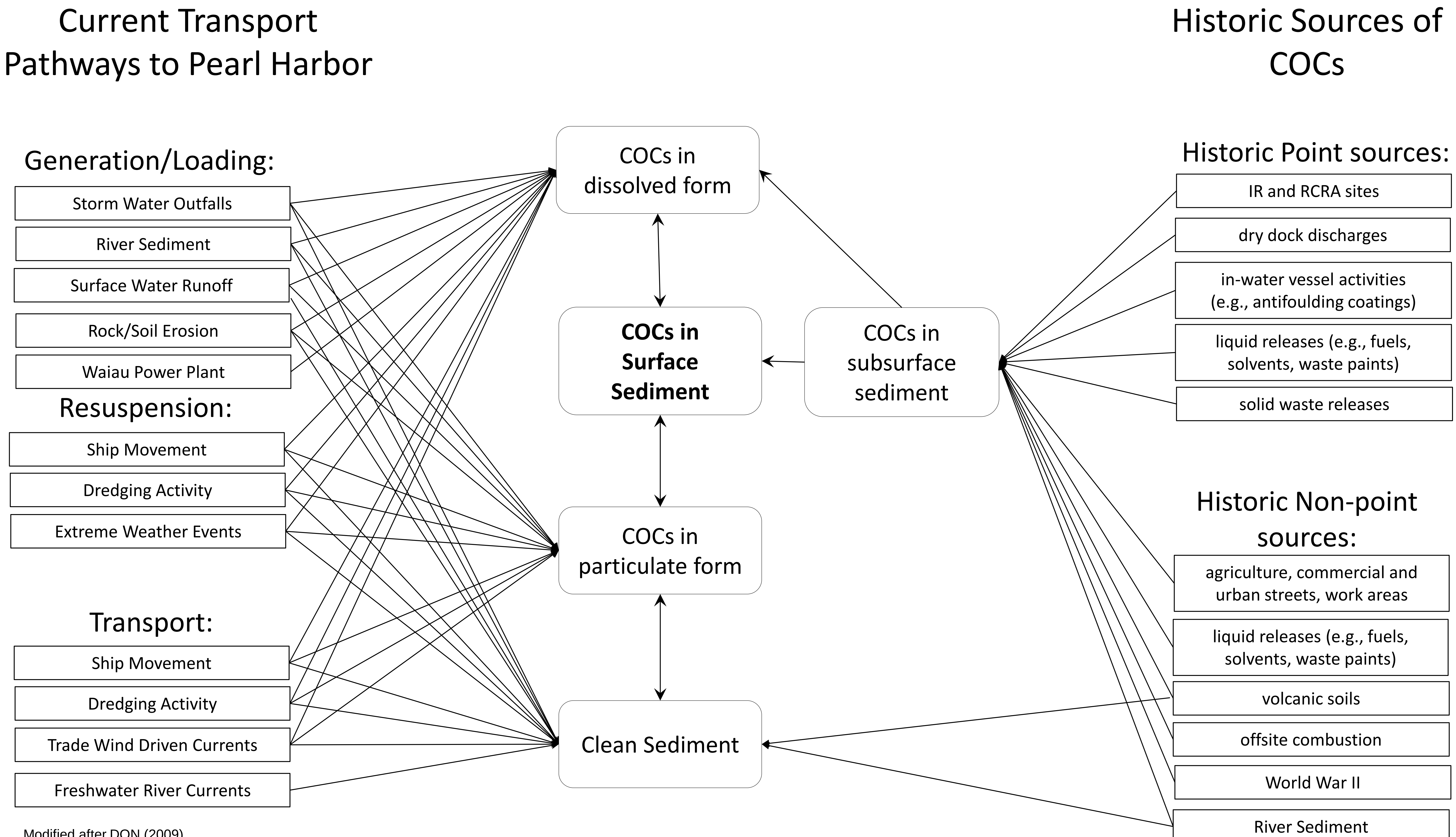


Figure 2-3
Fate and Transport Pathways for Chemicals to Sediments in Pearl Harbor
Pearl Harbor Sediment ROD
PHNC National Priorities List
JBPHH, Oahu, Hawaii

Contributing Source	Transport Mechanism	Exposure Route	Scenario	Onsite Residents (Adult/Child)	Onsite Subsistence Fishers/Crabbers (Adult/Child)	Onsite Recreational Users (Adult/Child)
Watershed-Based Point and Non-Point Sources						
Surface Runoff and Chemical Migration through Soil & Groundwater						
Surface Sediment	Direct Contact	Incidental Ingestion: Dermal Absorption:	Current:	Insignificant	Insignificant	Insignificant
			Future:	Insignificant	Insignificant	Insignificant

Rationale: Due to the variety of land uses surrounding the harbor, dermal contact with and ingestion of COCs in sediment by people fishing or crabbing and during recreational activities was identified as a potential pathway and evaluated in the risk assessment, but was found to be insignificant for current and future receptors.

Contributing Source	Transport Mechanism	Exposure Route	Scenario	Onsite Residents (Adult/Child)	Onsite Subsistence Fishers/Crabbers (Adult/Child)	Onsite Recreational Users (Adult/Child)
Surface Sediment	Bioaccumulation/ Bioconcentration	Ingestion of Fish/Shellfish:	Current:	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**
			Future:	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**

Rationale: Because of Pearl Harbor's size and the variety of land uses surrounding the harbor, several potentially exposed populations exist and may be exposed through ingestion of COCs in fish tissue. Therefore, the pathway for current and future onsite residential fisher/crabber, onsite subsistence fisher/crabber, and onsite recreational users is considered potentially complete.

Contributing Source	Transport Mechanism	Exposure Route	Scenario	Onsite Residents (Adult/Child)	Onsite Subsistence Fishers/Crabbers (Adult/Child)	Onsite Recreational Users (Adult/Child)
Surface Sediment	Windborne Particulates	Inhalation:	Current:	Incomplete	Incomplete	Incomplete
			Future:	Incomplete	Incomplete	Incomplete

Rationale: Inhalation of particulates is not considered a potentially complete pathway for fugitive dust from disturbed sediment because sediment is a "wet" medium and there would be no particulate available for suspension in air.

Contributing Source	Transport Mechanism	Exposure Route	Scenario	Onsite Residents (Adult/Child)	Onsite Subsistence Fishers/Crabbers (Adult/Child)	Onsite Recreational Users (Adult/Child)
Surface Sediment	Volatilization	Inhalation of VOCs:	Current:	Insignificant	Insignificant	Insignificant
			Future:	Insignificant	Insignificant	Insignificant

Rationale: VOCs have higher water solubility and lower tendencies for sorption to sediments than semivolatile organics and other chemicals. Therefore, VOCs are less likely to be present in marine sediments because of their selective depletion from evaporation and dissolution processes that influence levels of chemicals on particulates prior to deposition of the particulates into sediments in the harbor. In addition, sediments in the harbor are subject to considerable transport and redistribution processes (e.g., sediment resuspension and turbulent mixing) during which additional losses of VOCs are likely to occur (e.g., further dissolution losses for the more water-soluble chemicals). While small concentrations of VOCs could be present in the wet sediments, the risk assessment concluded that the inhalation of VOCs from disturbed wet sediments would be insignificant for both current and future receptors.

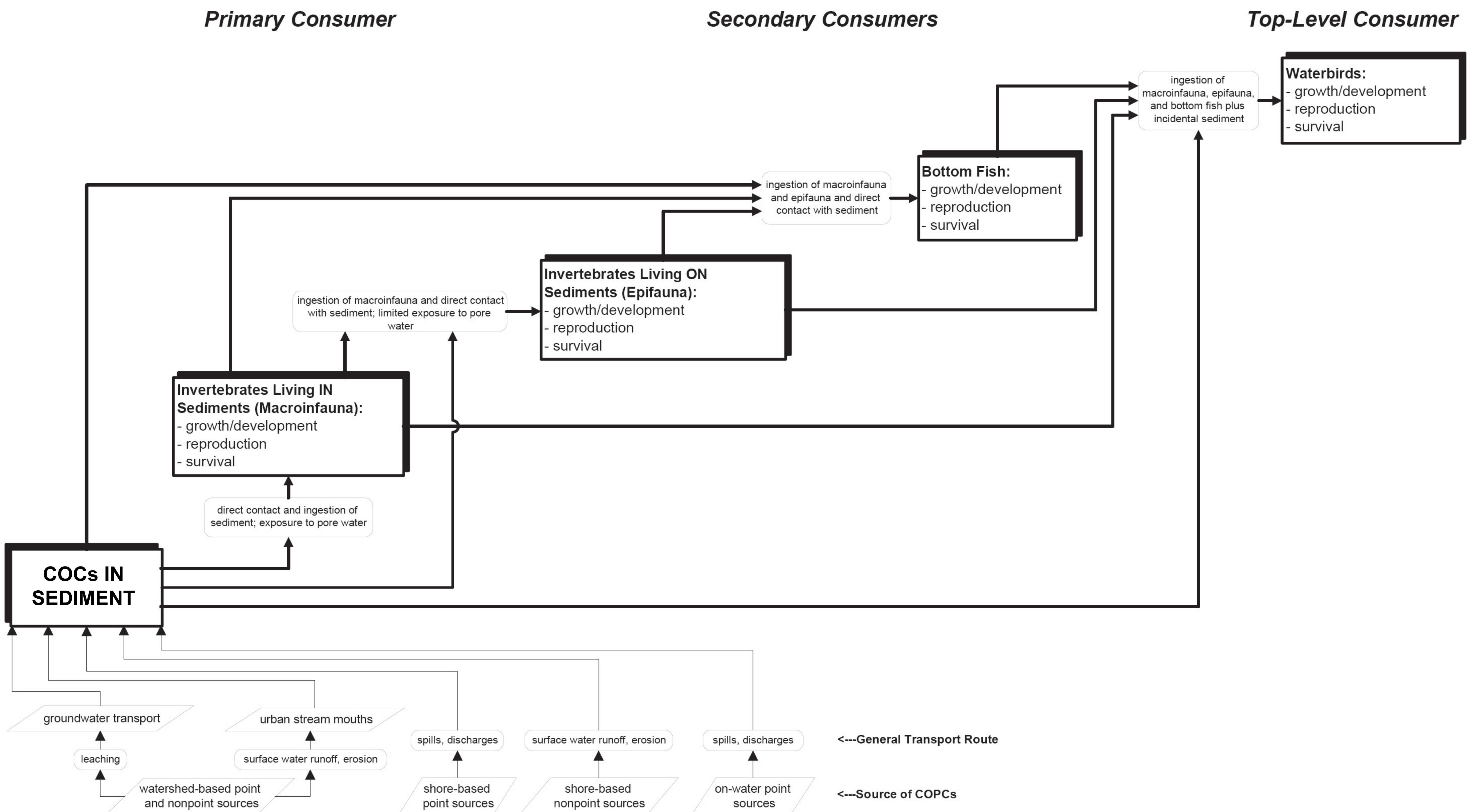
Contributing Source	Transport Mechanism	Exposure Route	Scenario	Onsite Residents (Adult/Child)	Onsite Subsistence Fishers/Crabbers (Adult/Child)	Onsite Recreational Users (Adult/Child)
Surface Water	Direct Contact	Incidental Ingestion: Dermal Absorption:	Current:	Insignificant	Insignificant	Insignificant
			Future:	Insignificant	Insignificant	Insignificant

Rationale: Due to the variety of land uses surrounding the harbor, dermal contact with and ingestion of COCs in surface water by people fishing or crabbing and during recreational activities was identified as a potential pathway and evaluated in the risk assessment, but was found to be insignificant for current and future receptors.

Contributing Source	Transport Mechanism	Exposure Route	Scenario	Onsite Residents (Adult/Child)	Onsite Subsistence Fishers/Crabbers (Adult/Child)	Onsite Recreational Users (Adult/Child)
Surface Water	Volatilization	Inhalation of VOCs:	Current:	Insignificant	Insignificant	Insignificant
			Future:	Insignificant	Insignificant	Insignificant

Rationale: VOCs are characterized by relatively high vapor pressures (i.e., volatilities) and water solubility (rapidly dilute) compared to other chemicals. Therefore, VOCs are less likely to be present in surface water because of their selective depletion from evaporation and dissolution processes. In addition, surface water in the harbor are subject to considerable turbulent mixing during which additional losses of VOCs are likely to occur (e.g., further dissolution losses for the more water-soluble chemicals). Because of the chemical properties of VOCs and the properties of the surface water medium, the inhalation of VOCs from the surface water medium is considered insignificant for both current and future receptors.

Figure 2-4
Conceptual Site Model for Human Health Risk Assessment for Pearl Harbor
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii



Source: DON (2009)

Figure 2-5
Conceptual Site Model for Chemicals in Sediments to Biological Receptors for Pearl Harbor
Pearl Harbor Sediment ROD
PHNC National Priorities List
JBPHH, Oahu, Hawaii

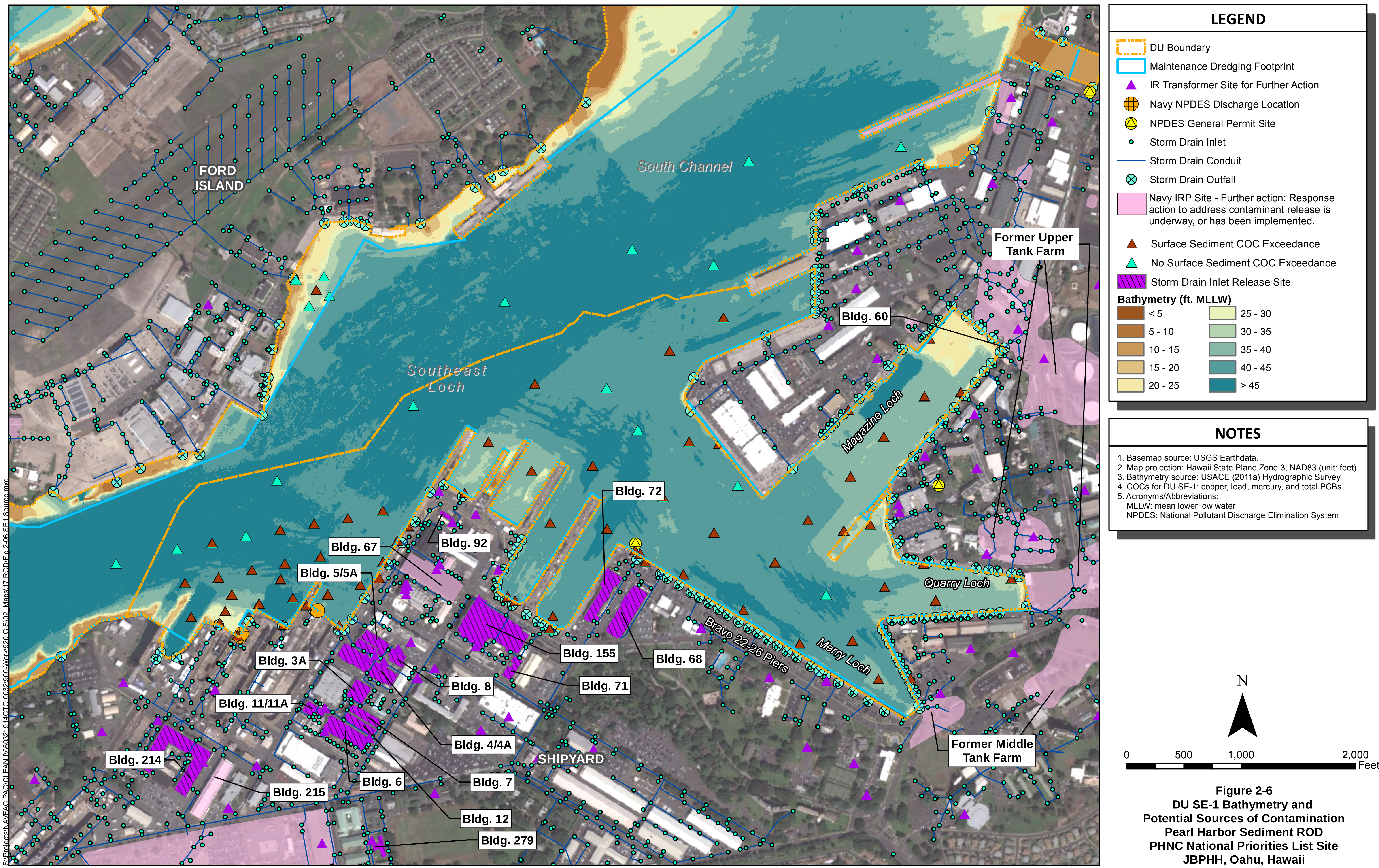
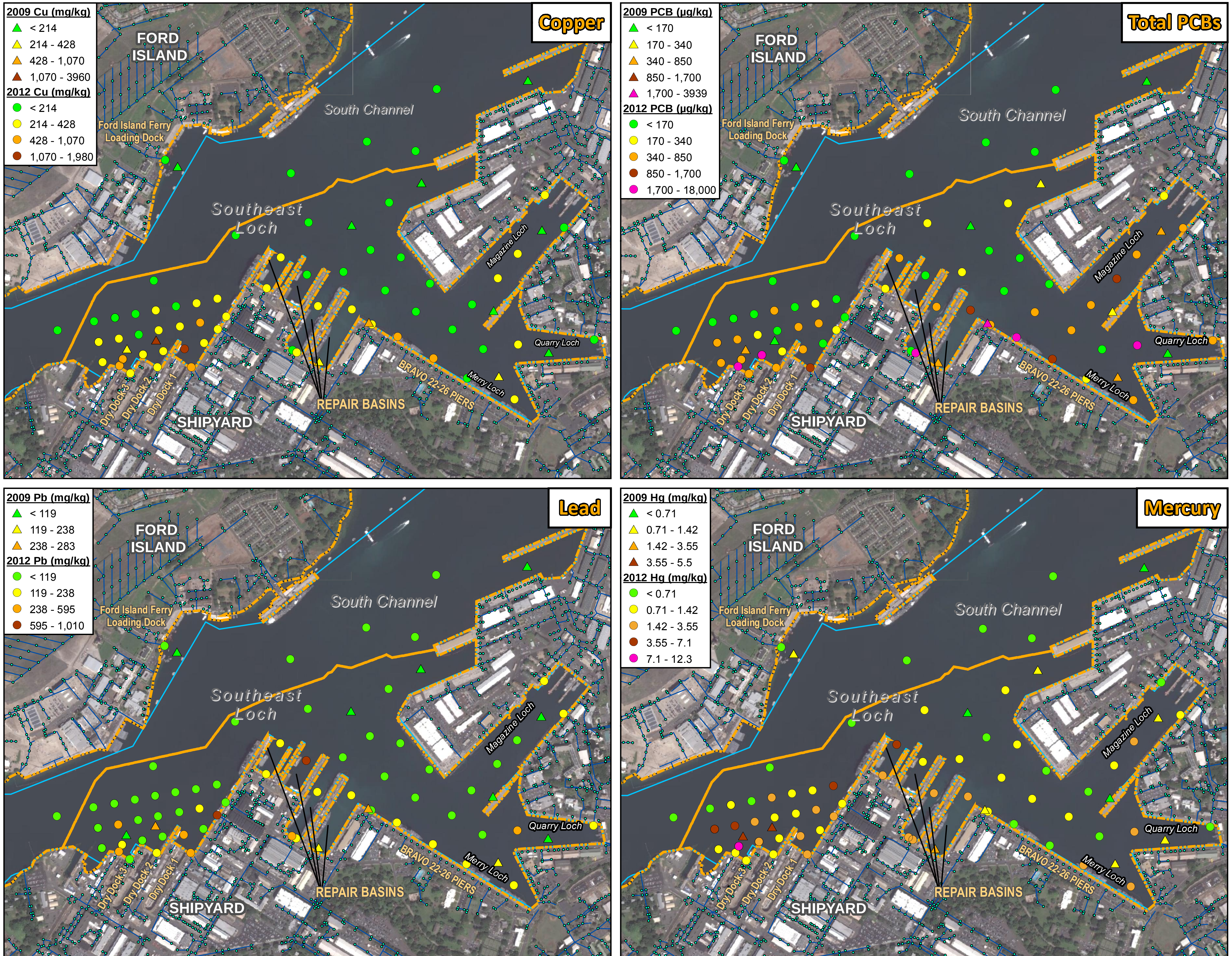


Figure 2-6
DU SE-1 Bathymetry and Potential Sources of Contamination
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii



LEGEND

2009 Surface Sediment Sampling Location:

- < Screening Criterion
- 1x - 2x Screening Criterion
- 2x - 5x Screening Criterion
- 5x - 10x Screening Criterion
- > 10x Screening Criterion

2012 Surface Sediment Sampling Location:

- < Screening Criterion
- 1x - 2x Screening Criterion
- 2x - 5x Screening Criterion
- 5x - 10x Screening Criterion
- > 10x Screening Criterion
- DU Boundary
- Maintenance Dredging Footprint
- Storm Drain Inlet
- Storm Drain Conduit

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Sediment Screening Criteria:

Analyte	Screening Criteria
Copper	214 mg/kg
Lead	119 mg/kg
Mercury	0.71 mg/kg
Dieldrin	14.4 µg/kg
Total Endosulfan	1.09 µg/kg
Total PCBs	170 µg/kg

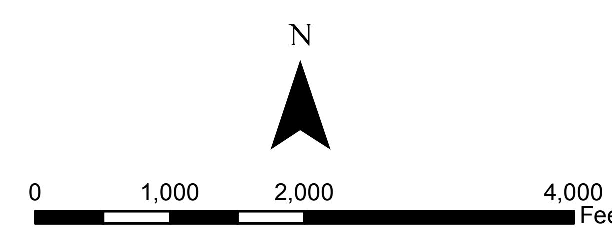
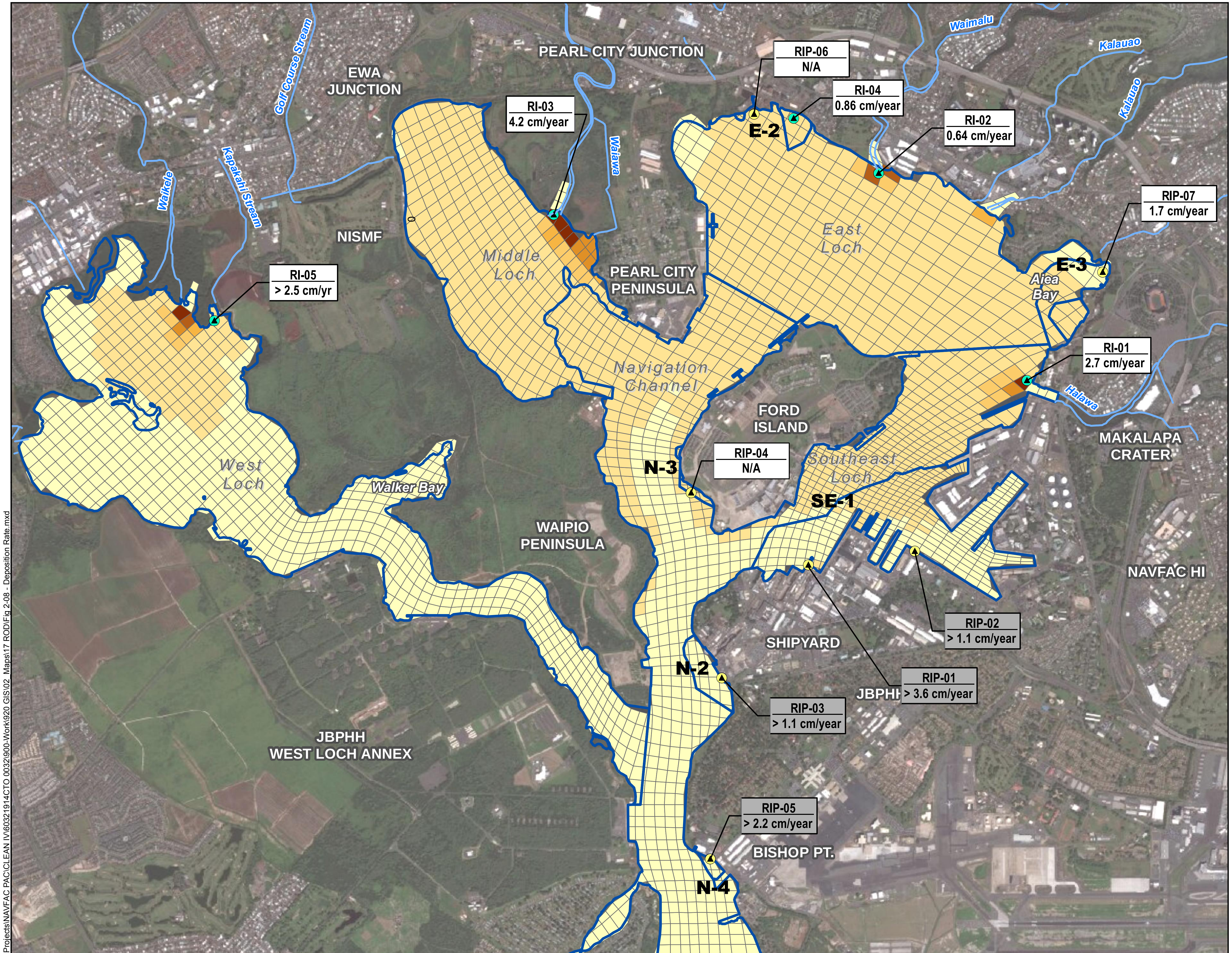


Figure 2-7
DU SE-1 COPC Concentration Distribution in Surface Sediment
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii



LEGEND

- 2012 Geochronology Sampling Location
- 2009 Geochronology Sampling Location

Average Deposition Rate (cm/year) (2009 Modeling)

- 0 - 0.1
- 0.1 - 0.6
- 0.6 - 1.2
- 1.2 - 2.0
- 2.0 - 5.0
- 5.0 - 10
- > 10
- DU Boundary
- Stream
- Under Pier Location

NOTES

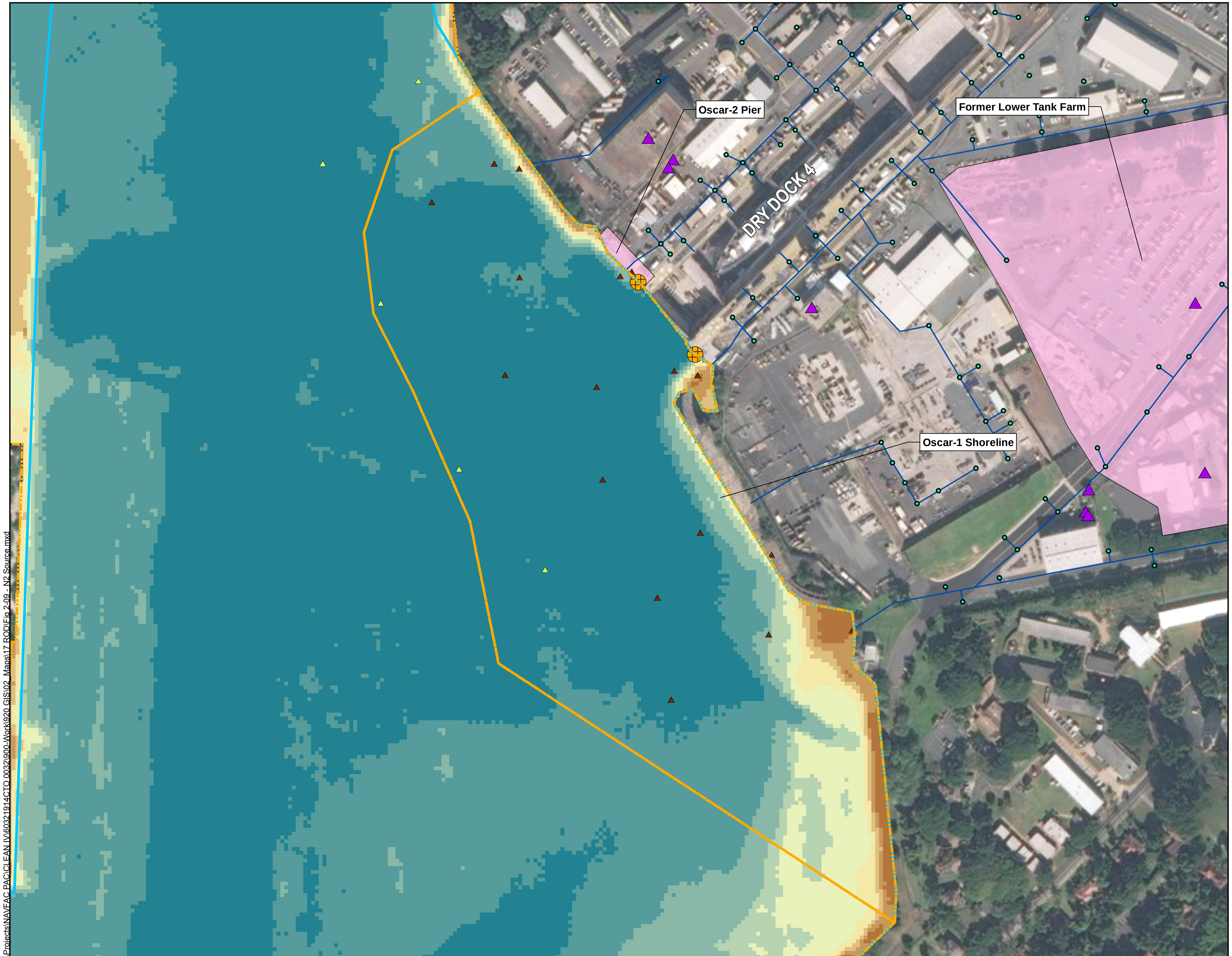
1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Radioisotope data from RI Addendum (2009 data) and FS field investigation (2012 data).
4. Average deposition rate derived from Tier 2 sediment transport model presented in RI Addendum report (DON 2013).

N

0 0.25 0.5 1 Mile

Figure 2-8
Sediment Net Deposition Rates
Derived from Tier 2 Sediment Transport Model and Radioisotope Geochronology
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914\CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-08 - Deposition Rate.mxd



LEGEND

- DU Boundary
- Maintenance Dredging Footprint
- IR Transformer Site for Further Action
- Navy NPDES Discharge Location
- Storm Drain Inlet
- Storm Drain Conduit
- Storm Drain Outfall
- Navy IRP Site - Further action: Response action to address contaminant release is underway, or has been implemented.
- Surface Sediment COC Exceedance
- No Surface Sediment COC Exceedance

Bathymetry (ft. MLLW)

< 5	25 - 30
5 - 10	30 - 35
10 - 15	35 - 40
15 - 20	40 - 45
20 - 25	> 45

NOTES

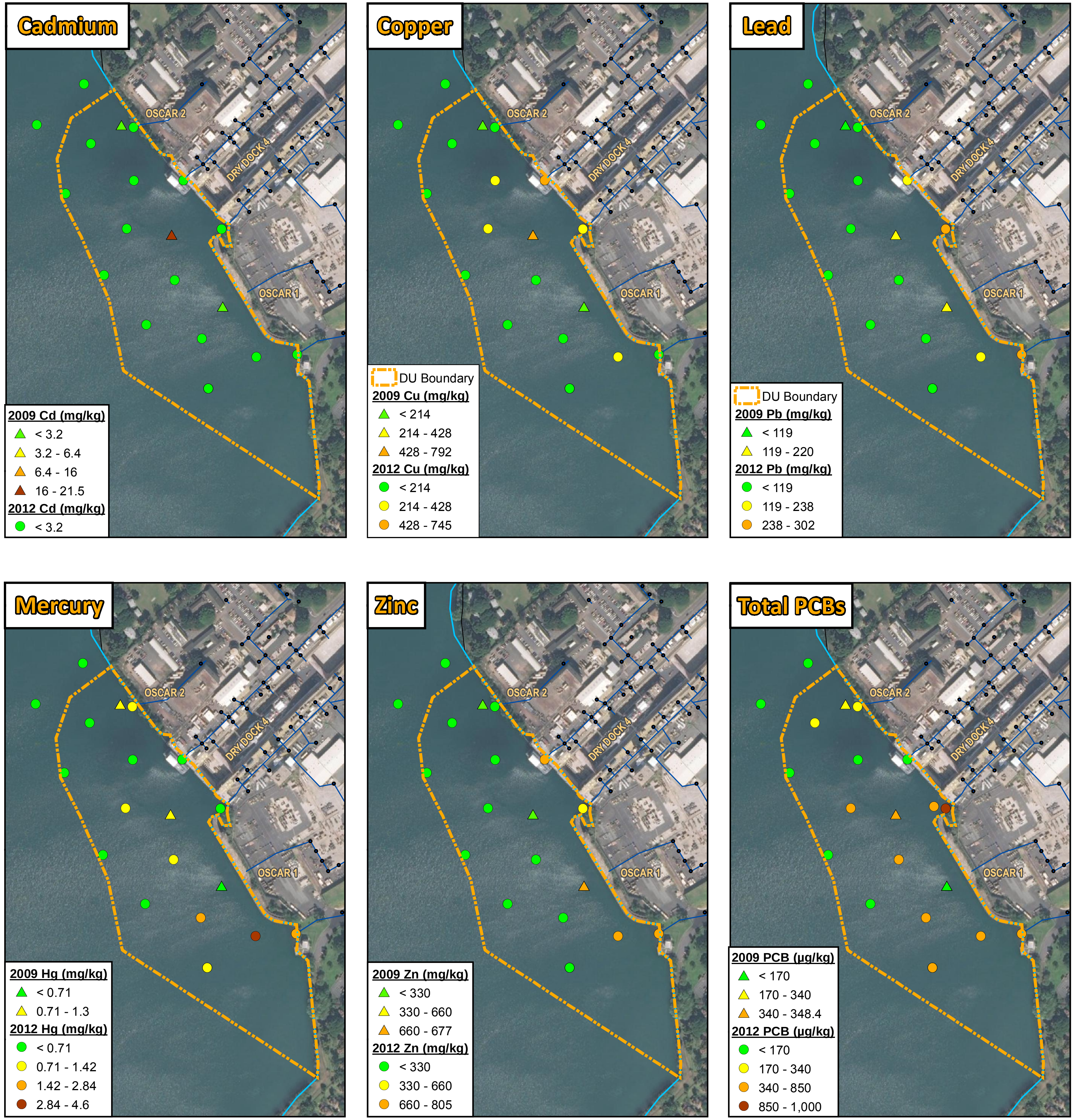
1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Bathymetry source: USACE (2011a) Hydrographic Survey.
4. COCs for DU N-2: cadmium, copper, lead, mercury, zinc, and total PCBs.
5. Acronyms/Abbreviations:
   MLLW: mean lower low water
   NPDES: National Pollutant Discharge Elimination System

N

0 150 300 600 Feet

Figure 2-9
DU N-2 Bathymetry and Potential Sources of Contamination
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-09 - N2 Source.mxd



LEGEND

2009 Surface Sediment Sampling Location:

- < Screening Criterion
- 1x - 2x Screening Criterion
- 2x - 5x Screening Criterion
- 5x - 10x Screening Criterion

2012 Surface Sediment Sampling Location:

- < Screening Criterion
- 1x - 2x Screening Criterion
- 2x - 5x Screening Criterion
- 5x - 10x Screening Criterion
- Maintenance Dredging Footprint
- Storm Drain Inlet
- Storm Drain Conduit

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Sediment Screening Criteria:

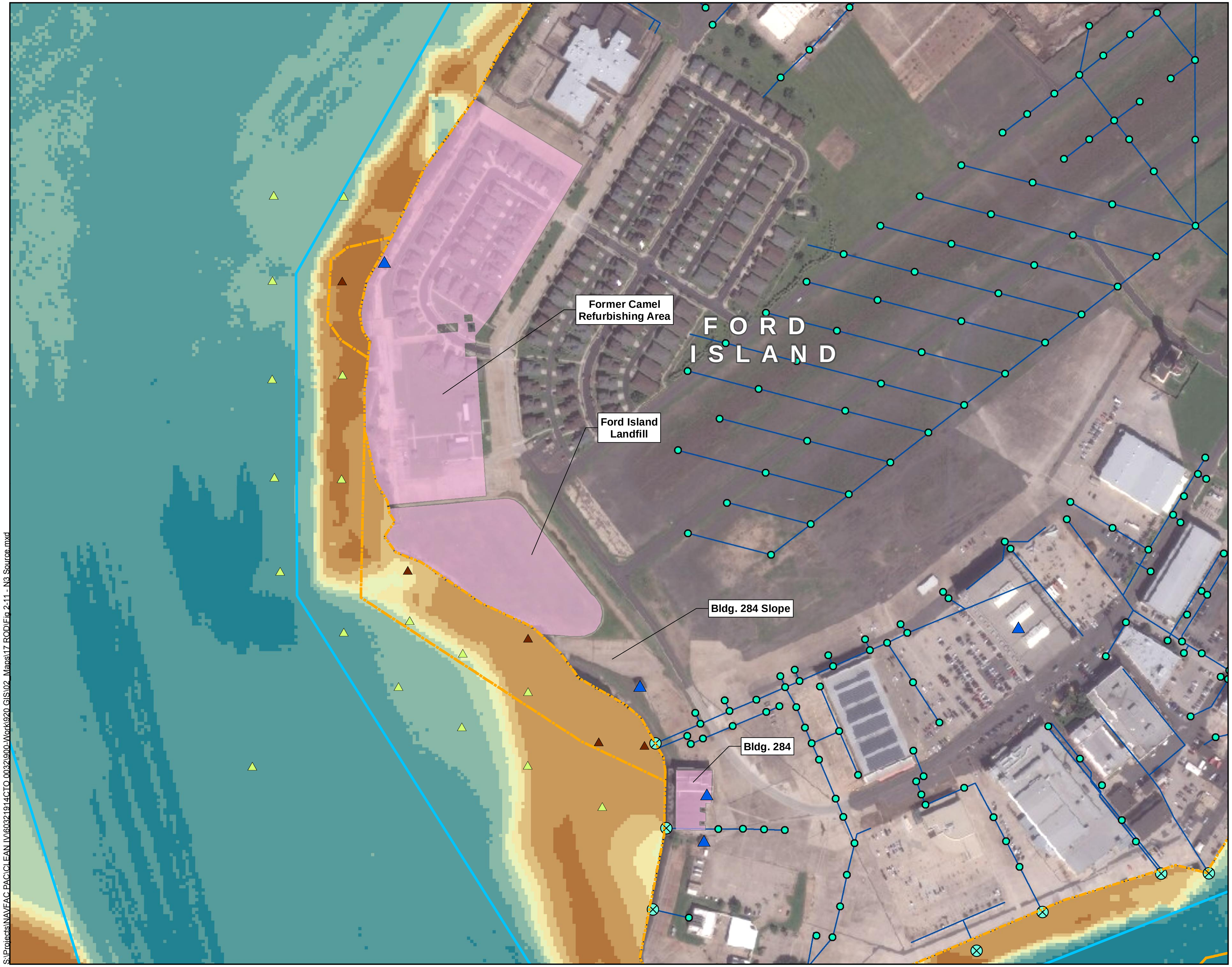
Analyte	Screening Criteria
Cadmium	3.2 mg/kg
Copper	214 mg/kg
Lead	119 mg/kg
Mercury	0.71 mg/kg
Zinc	330 mg/kg
Dieldrin	14.4 µg/kg
Total PCBs	170 µg/kg

N

0 375 750 1,500 Feet

Figure 2-10
DU N-2 COPC Concentration Distribution in Surface Sediment
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-10 - N2 COC Surf Sed.mxd



LEGEND

- DU Boundary
- Maintenance Dredging Footprint
- IR Transformer Site with No Further Action
- Storm Drain Outfall
- Storm Drain Inlet
- Storm Drain Conduit
- Navy IRP Site - Further action: Response action to address contaminant release is underway, or has been implemented.
- Surface Sediment COC Exceedance
- No Surface Sediment COC Exceedance

Bathymetry (ft. MLLW)

< 5	25 - 30
5 - 10	30 - 35
10 - 15	35 - 40
15 - 20	40 - 45
20 - 25	> 45

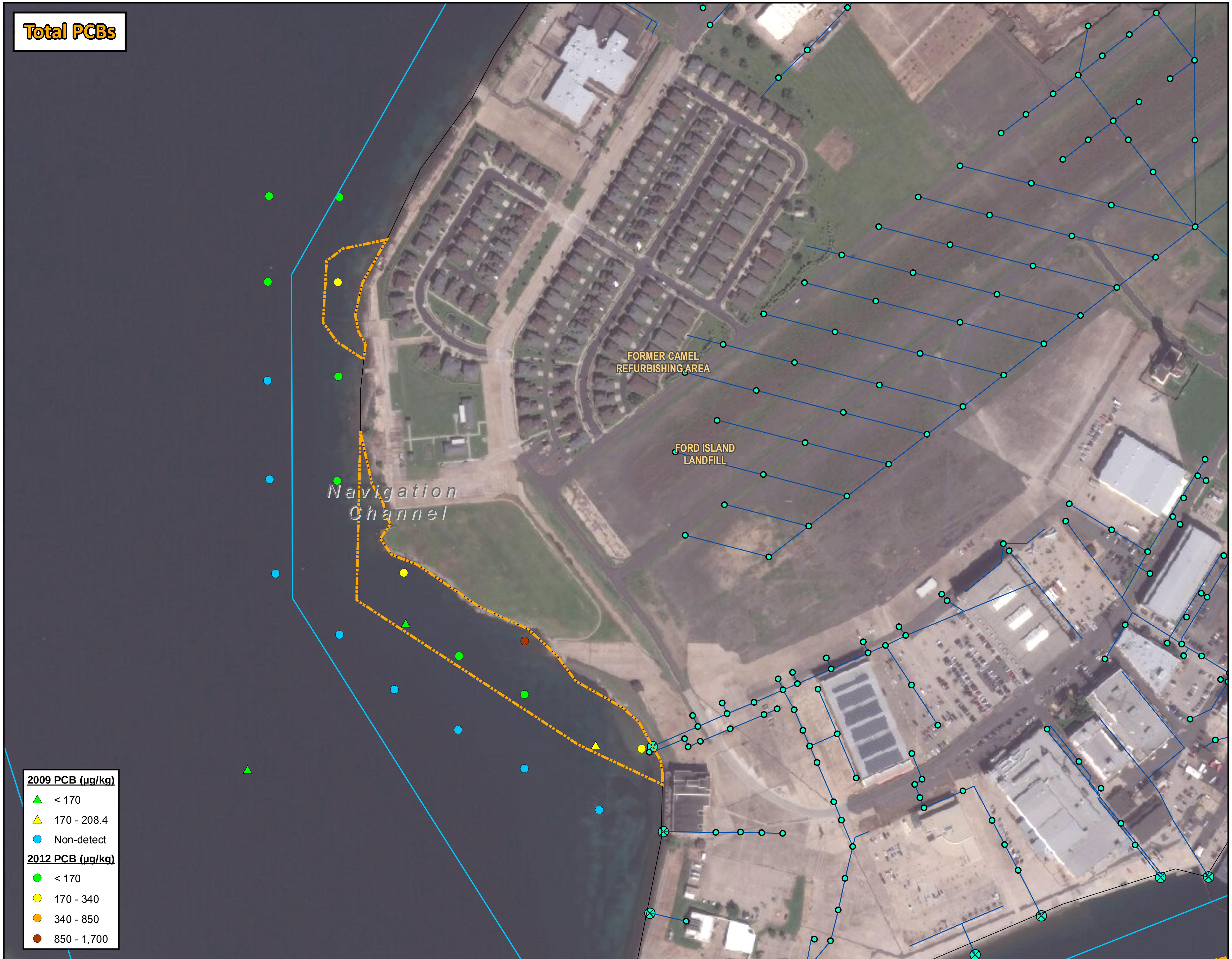
NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. COC for DU N-3: total PCBs
4. Acronyms/Abbreviations:
   MLLW: mean lower low water.
   Bathymetry source: USACE (2011a) Hydrographic Survey.

N

0 175 350 700 Feet

Figure 2-11
DU N-3 Bathymetry and
Potential Sources of Contamination
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii



LEGEND

2009 Surface Sediment Sampling Location:
- < Screening Criterion
- 1x - 2x Screening Criterion

2012 Surface Sediment Sampling Location:
- < Screening Criterion
- 1x - 2x Screening Criterion
- 5x - 10x Screening Criterion
- Non-Detect

- DU Boundary
- Maintenance Dredging Footprint
- Storm Drain Inlet
- Storm Drain Conduit
- Storm Drain Outfall

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Sediment Screening Criteria:

Analyte	Screening Criteria
Dieldrin	14.4 µg/kg
Total PCBs	170 µg/kg

N

0 175 350 700 Feet

Figure 2-12
DU N-3 COPC Concentration Distribution in Surface Sediment
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-12 - N3 COC Surf Sed.mxd

LEGEND

- DU Boundary
- Maintenance Dredging Footprint
- NPDES General Permit Site
- IR Transformer Site for Further Action
- IR UST Site for Further Action
- Storm Drain Conduit
- Storm Drain Outfall
- Surface Sediment COC Exceedance
- No Surface Sediment COC Exceedance

Bathymetry (ft. MLLW)

< 5	25 - 30
5 - 10	30 - 35
10 - 15	35 - 40
15 - 20	40 - 45
20 - 25	> 45

NOTES

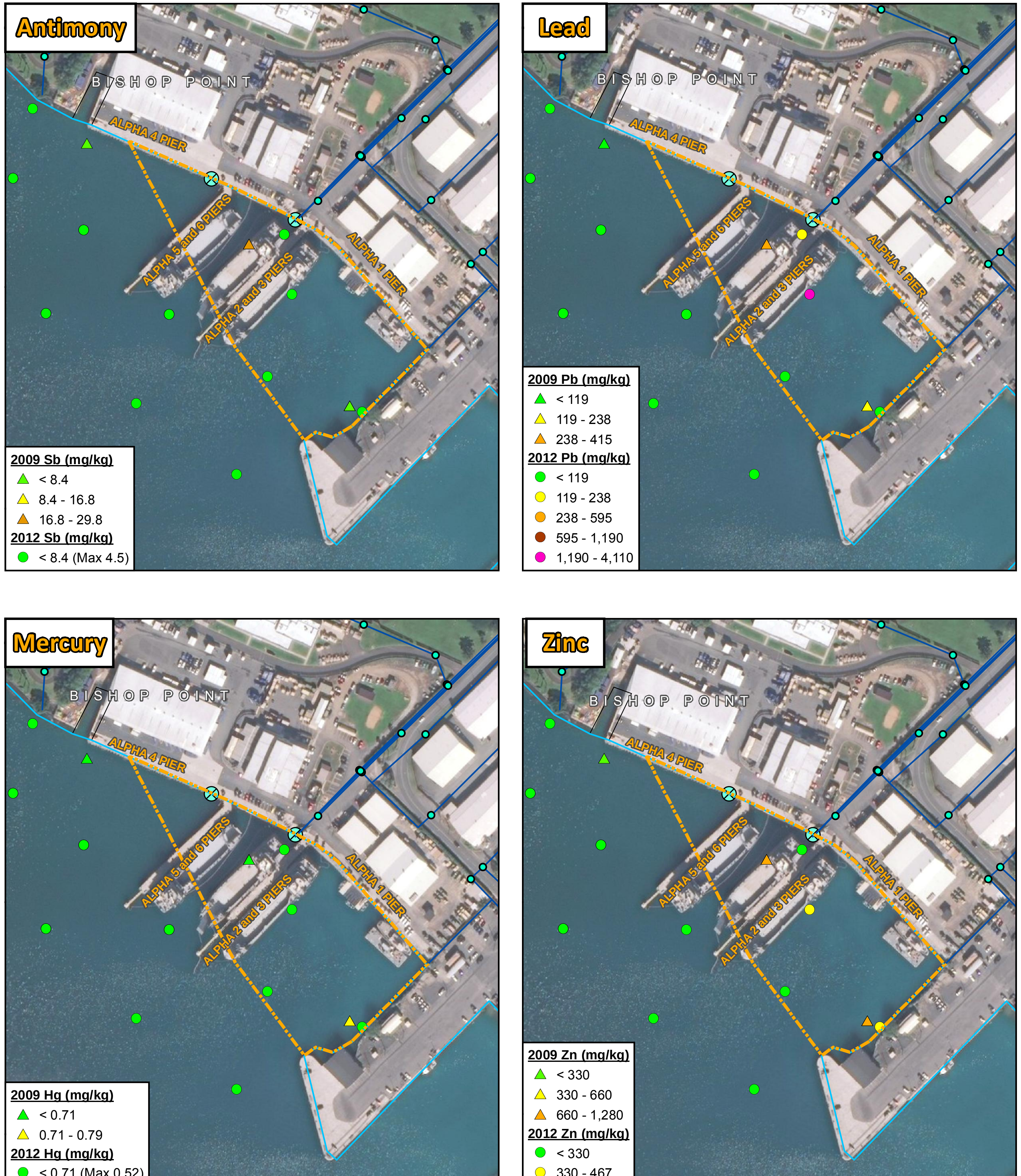
1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Bathymetry source: USACE (2011a) Hydrographic Survey.
4. COCs for DU N-4: antimony, lead, mercury, and zinc
5. Acronyms/Abbreviations:
   MLLW: mean lower low water
   NPDES: National Pollutant Discharge Elimination System
   UST: underground storage tank

N

0 100 200 400 Feet

Figure 2-13
DU N-4 Bathymetry and Potential Sources of Contamination
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-13 - N4 Source.mxd



LEGEND

2009 Surface Sediment Sampling Location:

- < Screening Criterion
- 1x - 2x Screening Criterion
- 2x - 5x Screening Criterion

2012 Surface Sediment Sampling Location:

- < Screening Criterion
- 1x - 2x Screening Criterion
- > 10x Screening Criterion
- DU Boundary
- Maintenance Dredging Footprint
- Storm Drain Inlet
- Storm Drain Conduit
- Storm Drain Outfall

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Sediment Screening Criteria:

Analyte	Screening Criteria
Antimony	8.4 mg/kg
Lead	119 mg/kg
Mercury	0.71 mg/kg
Zinc	330 mg/kg
Total Endosulfan	1.09 µg/kg

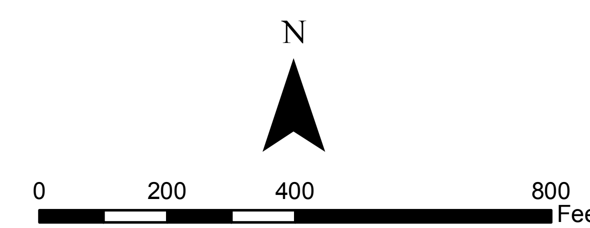


Figure 2-14
DU N-4 COPC Concentration Distribution in Surface Sediment
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-14 - N4 COC Surf Sed.mxd

LEGEND

- Waiau Power Plant Property Boundary
- Maintenance Dredging Footprint
- DU Boundary
- NPDES General Permit Site
- DOH & EPA: RCRA High Priority NCAPS Site
- Stream
- City and County of Honolulu Storm Drain Inlet
- City & County of Honolulu Storm Drain Inlet and Outfall
- City & County of Honolulu Storm Drain Conduit
- Waiau Power P. — Potential Non-Navy Sediment Contamination Source
- Surface Sediment with No COC Exceedance
- Surface Sediment with COC Exceedance

Bathymetry (ft. MLLW)

< 5	25 - 30
5 - 10	30 - 35
10 - 15	35 - 40
15 - 20	40 - 45
20 - 25	> 45

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Bathymetry source: 2015 Single-beam Hydrographic Survey.
4. COCs for DU E-2: total PCBs.
5. Acronyms/Abbreviations:
   MLLW: mean lower low water
   NPDES: National Pollutant Discharge Elimination System
   NCAPS: National Corrective Action Prioritization System

N

0 175 350 700 Feet

Figure 2-15
DU E-2 Bathymetry and Potential Sources of Contamination
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-15 - F2 Source.mxd

LEGEND

2009 Surface Sediment Sampling Location:
- < Screening Criterion
- 1x -2x Screening Criterion

2012 Surface Sediment Sampling Location:
- < Screening Criterion
- 1x - 2x Screening Criterion
- 2x - 5x Screening Criterion
- > 10x Screening Criterion
- Non-Detect
- DU Boundary
- Maintenance Dredging Footprint
- City & County of Honolulu Storm Drain Inlet
- City & County of Honolulu Storm Drain Conduit
- Stream

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Sediment screening criterion for Total PCBs is 170 µg/kg.

N

0 175 350 700 Feet

Figure 2-16
DU E-2 Lateral Distribution of COPC Concentrations in Surface Sediment
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-16 - E2 COC Surf Sed.mxd

LEGEND

- Maintenance Dredging Footprint
- DU Boundary
- NPDES General Permit Site
- City & County of Honolulu Storm Drain Outfall
- Navy Storm Drain Outfall
- IR Transformer Site for Further Action
- Formerly Used Defense Site
- Navy IRP Site - Further action: Response action to address contaminant release is underway, or has been implemented.
- Surface Sediment COC Exceedance
- No Surface Sediment COC Exceedance
- Stream

Bathymetry (ft. MLLW)

2	12
4	14
6	16
8	18
10	20

NOTES

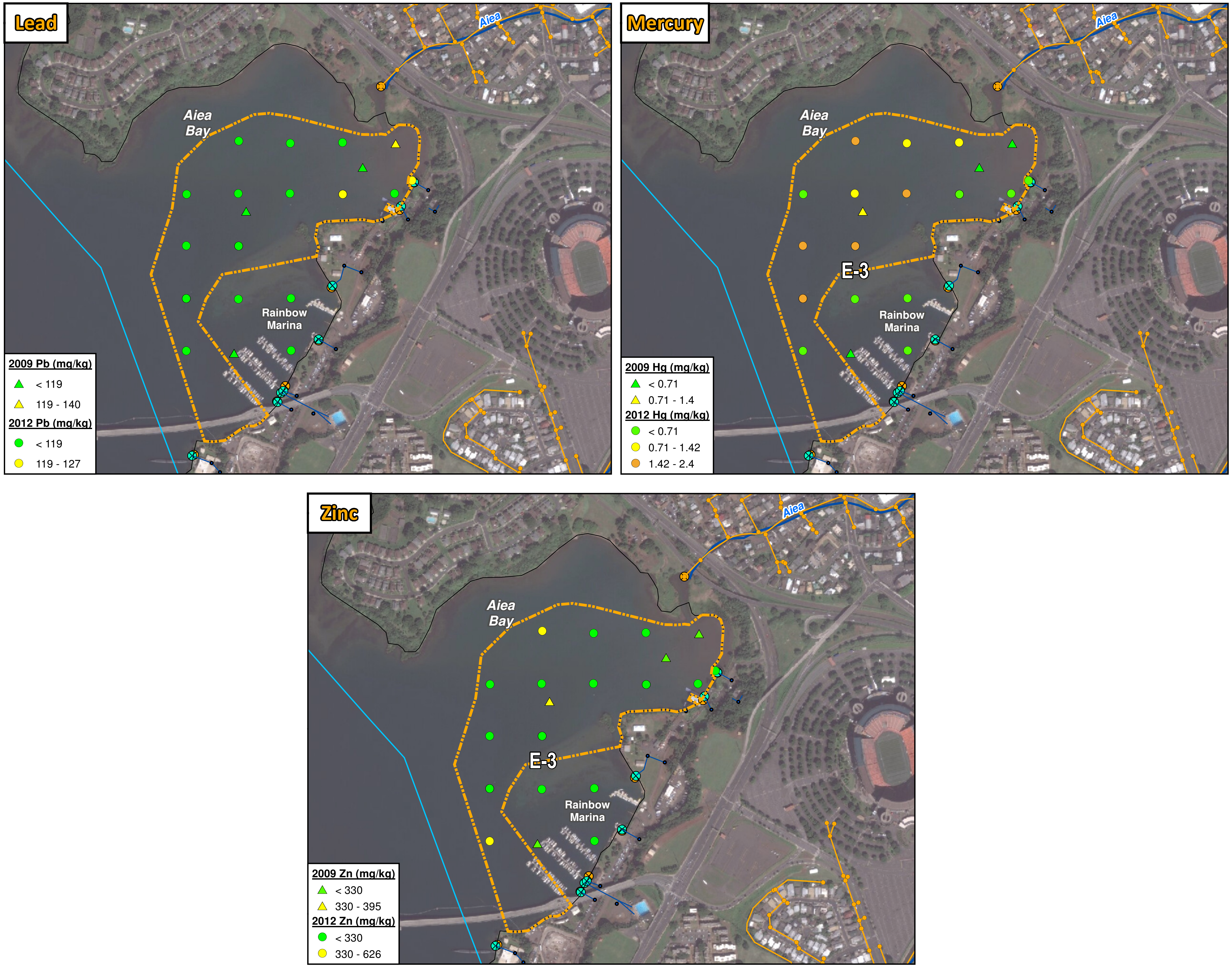
1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Bathymetry source: 2012 Single-beam Hydrographic Survey.
4. COCs for DU E-3: lead, mercury, and zinc.
5. NPDES: National Pollutant Discharge Elimination System

N

0 175 350 700 Feet

Figure 2-17
DU E-3 Bathymetry and Potential Sources of Contamination
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects_Legacy\ENV\Federal\NAVY\CLEAN III\CTO 0046 (60193997)\50_Data\GIS\16_ROD\Fig 2-17 - E3_Bathymetry_and_NavyNonNavy_Sources_rev1.mxd



LEGEND

2009 Surface Sediment Sampling Location:

- < Screening Criterion
- 1x - 2x Screening Criterion
- 2x - 5x Screening Criterion
- 5x - 10x Screening Criterion
- > 10x Screening Criterion

2012 Surface Sediment Sampling Location:

- < Screening Criterion
- 1x - 2x Screening Criterion
- 2x - 5x Screening Criterion
- DU Boundary
- Maintenance Dredging Footprint
- Navy Storm Drain Inlet
- Navy Storm Drain Conduit
- Navy Storm Drain Outfall
- City & County of Honolulu Storm Drain Inlet
- City & County of Honolulu Storm Drain Conduit
- City & County of Honolulu Storm Drain Outfall
- Stream

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. Sediment Screening Criteria:

Analyte	Screening Criteria
Lead	119 mg/kg
Mercury	0.71 mg/kg
Silver	1.8 mg/kg
Zinc	330 mg/kg

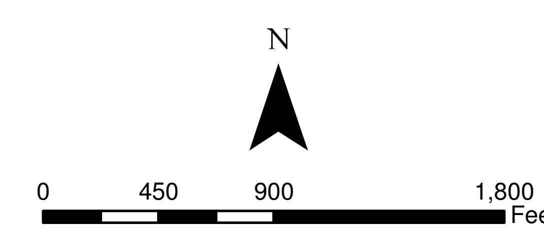
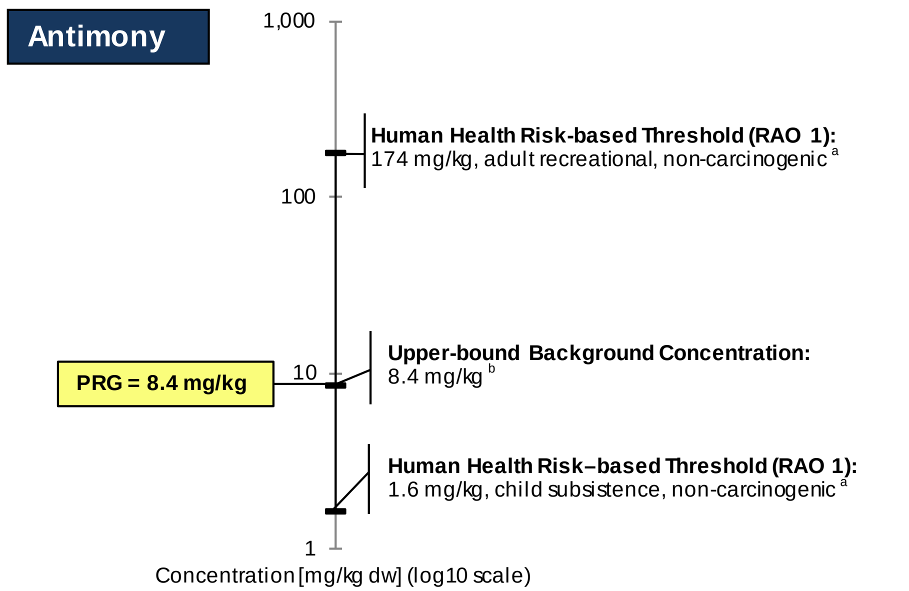
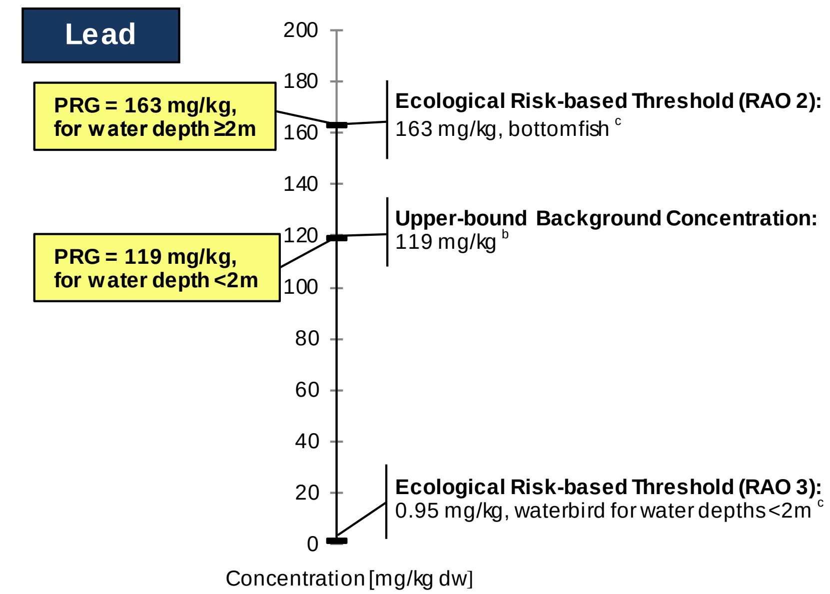
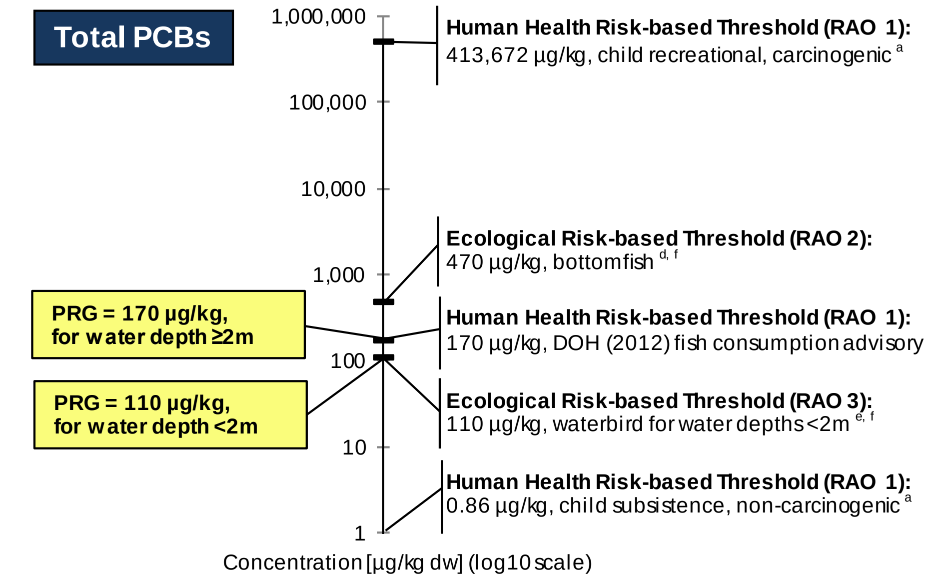


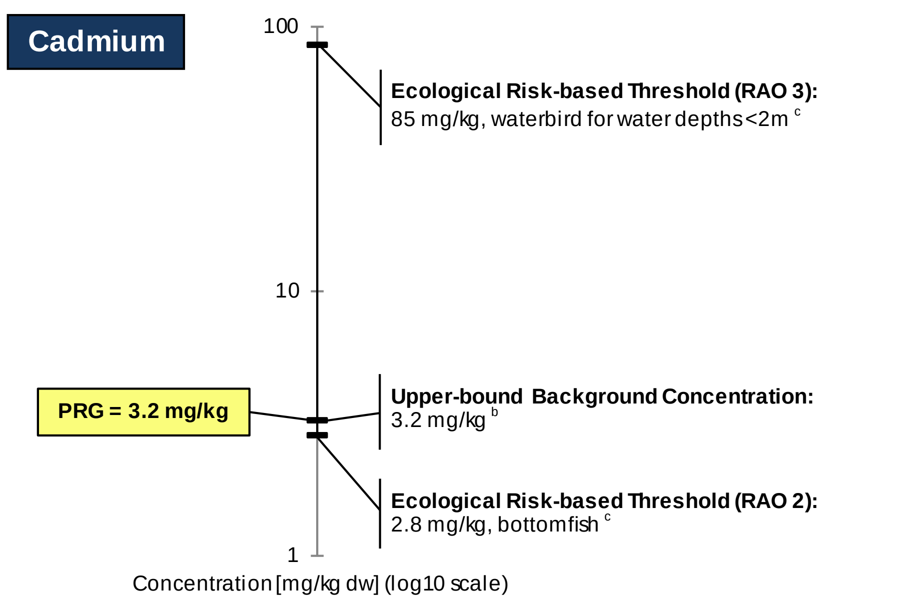
Figure 2-18
DU E-3 Lateral Distribution of COPC Concentrations in Surface Sediment
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

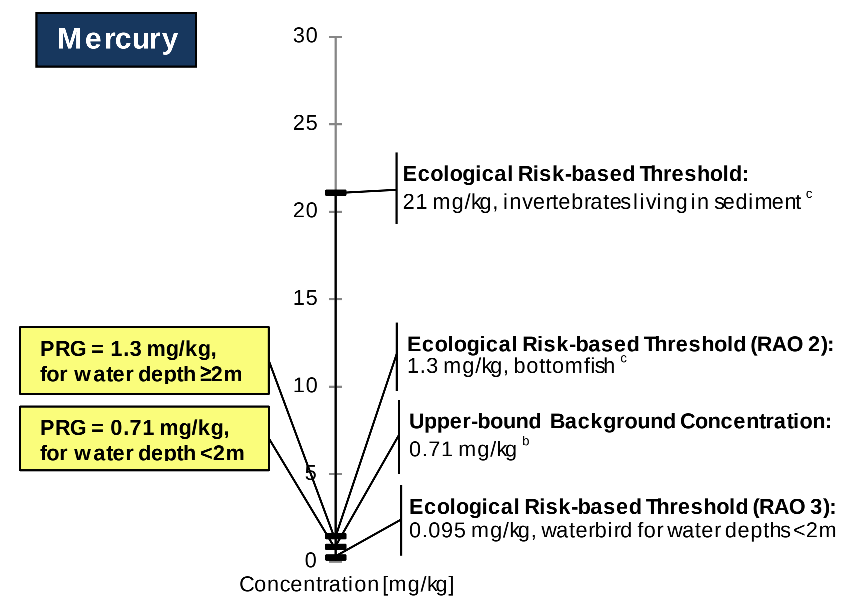
S:\Projects_Legacy\ENV\Federal\NAVY\CLEAN III\CTO 0046 (60193997)\50_Data\GIS\16_ROD\Fig 2-18 - E3_Surface_Sed_Data\LatDistr|_rev2.mxd

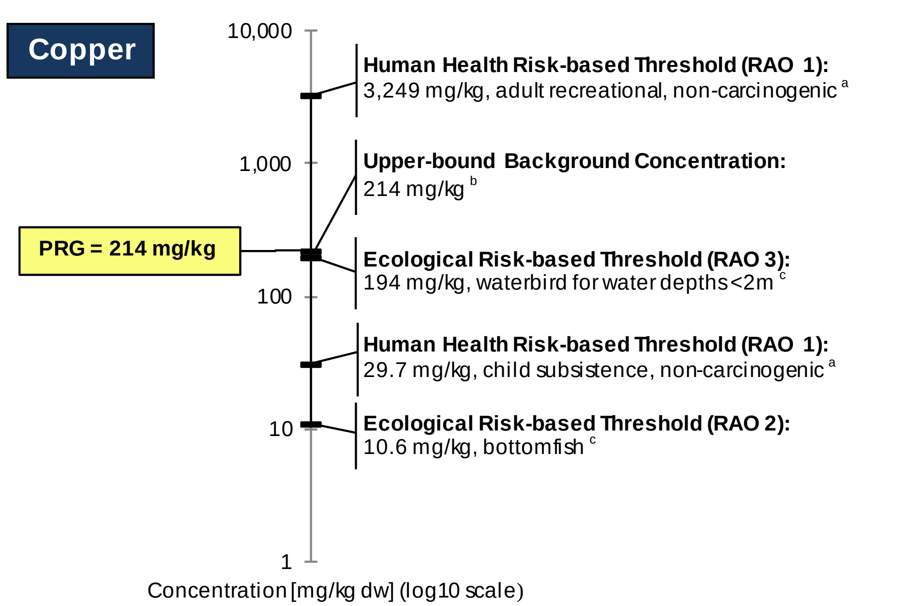


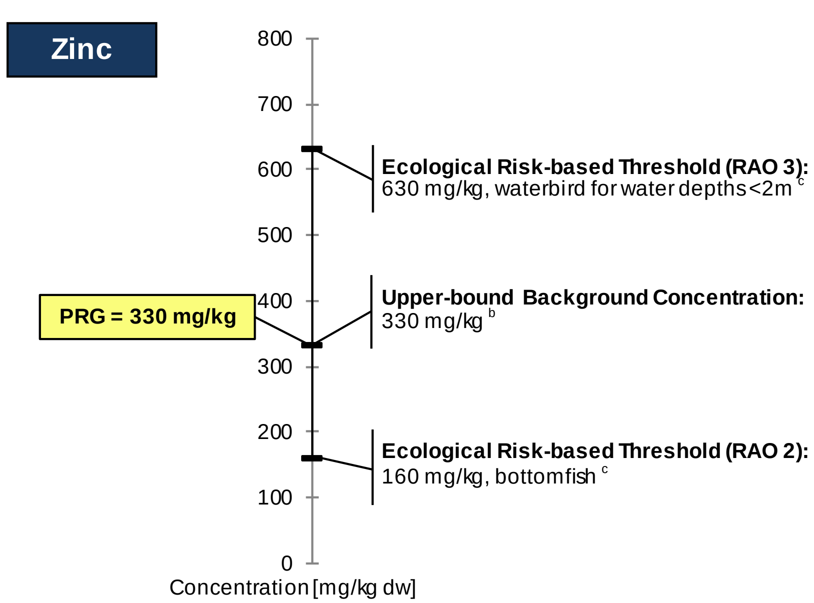












Notes:

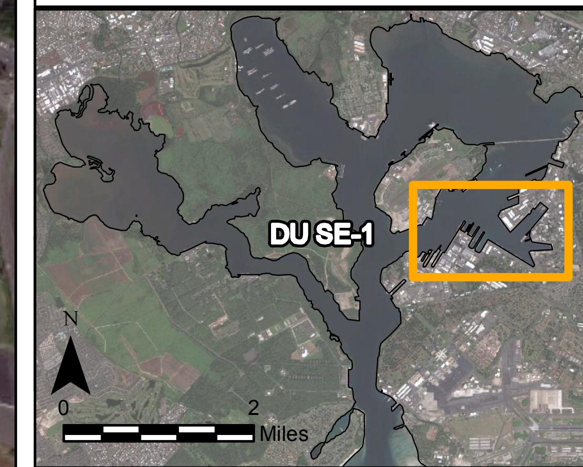
Ecological criterion was not calculated for antimony because no ecotoxicity reference value was available for fish.
Site-specific background concentration was not developed for total PCBs.
Human health carcinogenic values are based on a 10^{-4} cancer risk; ecological risk values are based on HQ=1.

µg/kg	microgram per kilogram
mg/kg	milligram per kilogram
dw	dry weight
m	meter
PRG	preliminary remediation goal
RAO	remedial action objective

[a] Based on HHRA (DON 2007a, Appendix I). Six scenarios evaluated include residential, subsistence, and recreational for adults and children. Maximum and minimum values shown.
[b] From Pearl Harbor Sediment Environmental Background Analysis (DON 2006, Appendix H).
[c] Based on BERA (DON 2007a, Appendix M).
[d] Deep-water ecological risk-based criterion from the RI Addendum report (DON 2013, Appendix D.1); based on harbor-wide BSAF median value of 3.9 and CTV of value of 5,392 µg/kg dry weight tissue defined in the BERA (DON 2007a).
[e] Shallow-water ecological risk-based criterion from the RI Addendum report (DON 2013); based on the toxicity reference value of 0.11 mg/kg-day from the BERA (derived using the "Rule of 5" intermediate value between the NOAEL and LOAEL) for birds, and assuming average organic carbon in sediment, and average moisture content and lipid content in fish, using the exposure assumptions developed for the BERA (DON 2007a).
[f] Updated criteria based on 2009 data for total PCBs (Final RI Addendum report Appendix D.1 [DON 2013]).

Figure 2-19
Pearl Harbor Sediment Preliminary Remediation Goals
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

LOCATION MAP



LEGEND

- Maintenance Dredging Footprint
- Dredging Remedy Footprint
- ENR Remedy Footprint
- ENR + AC Remedy Footprint
- MNR Remedy Footprint
- MNR + AC Remedy Footprint
- No Remediation Required Area
- Under-pier AC Treatment Area
- Under-pier MNR Area

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. AC in-situ activated carbon treatment.
   ENR enhanced natural recovery
   ENR+AC enhanced natural recovery + AC treatment
   MNR monitored natural recovery
   MNR+AC monitored natural recovery + AC treatment

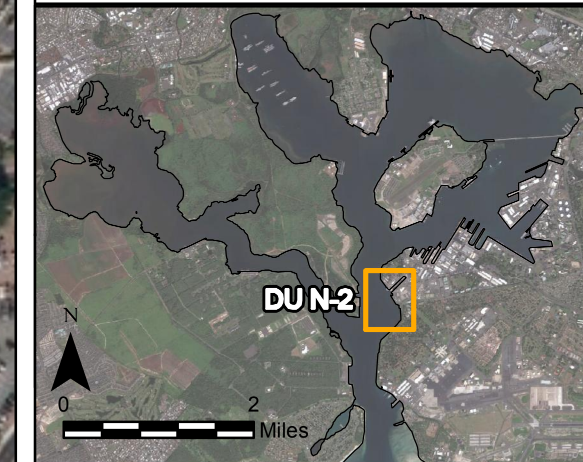
N

0 500 1,000 2,000 Feet

Figure 2-20
DU SE-1 Selected Remedial Alternative
Alternative 13 - Focused Dredging with ENR, AC, and MNR (20 Years)
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-20 - SE1 Footprint.mxd

LOCATION MAP



LEGEND

- Maintenance Dredging Footprint
- ENR Remedy Footprint
- MNR Remedy Footprint
- No Remediation Required Area
- Under-pier AC Treatment Area

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 datum (unit: feet).
3. AC in-situ activated carbon treatment.
   ENR enhanced natural recovery
   MNR monitored natural recovery

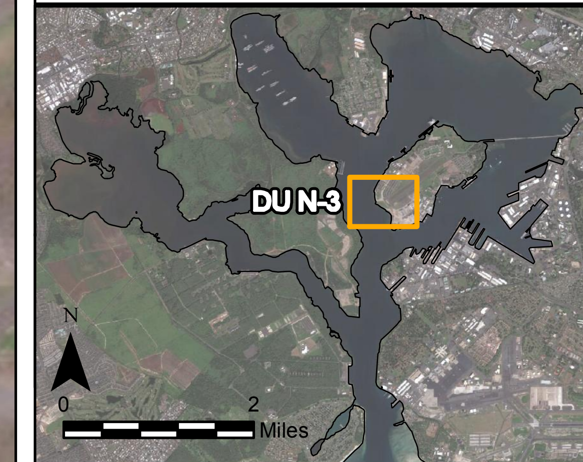
N

0 125 250 500 Feet

Figure 2-21
DU N-2 Selected Remedial Alternative
Alternative 10 - ENR with MNR (10 Years)
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-21 - DU N2 Footprint.mxd

LOCATION MAP



LEGEND

- Maintenance Dredging Footprint
- ENR Remedy Footprint
- No Remediation Required Area

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. ENR enhanced natural recovery

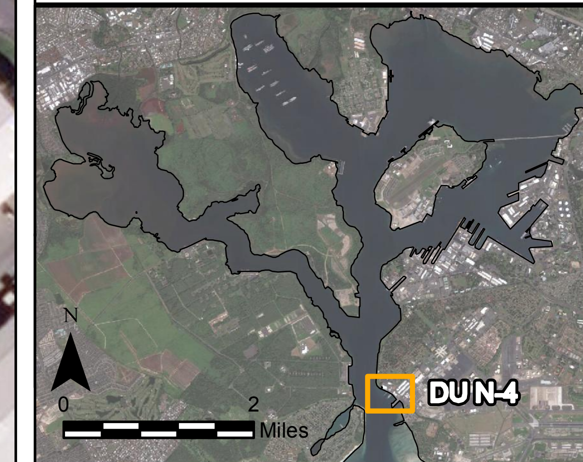
N

0 125 250 500 Feet

Figure 2-22
DU N-3 Selected Remedial Alternative
Alternative 4 - ENR
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-22 - DU N3 Footprint.mxd

LOCATION MAP



LEGEND

- ENR Remedy Footprint
- No Remediation Required Area

NOTES

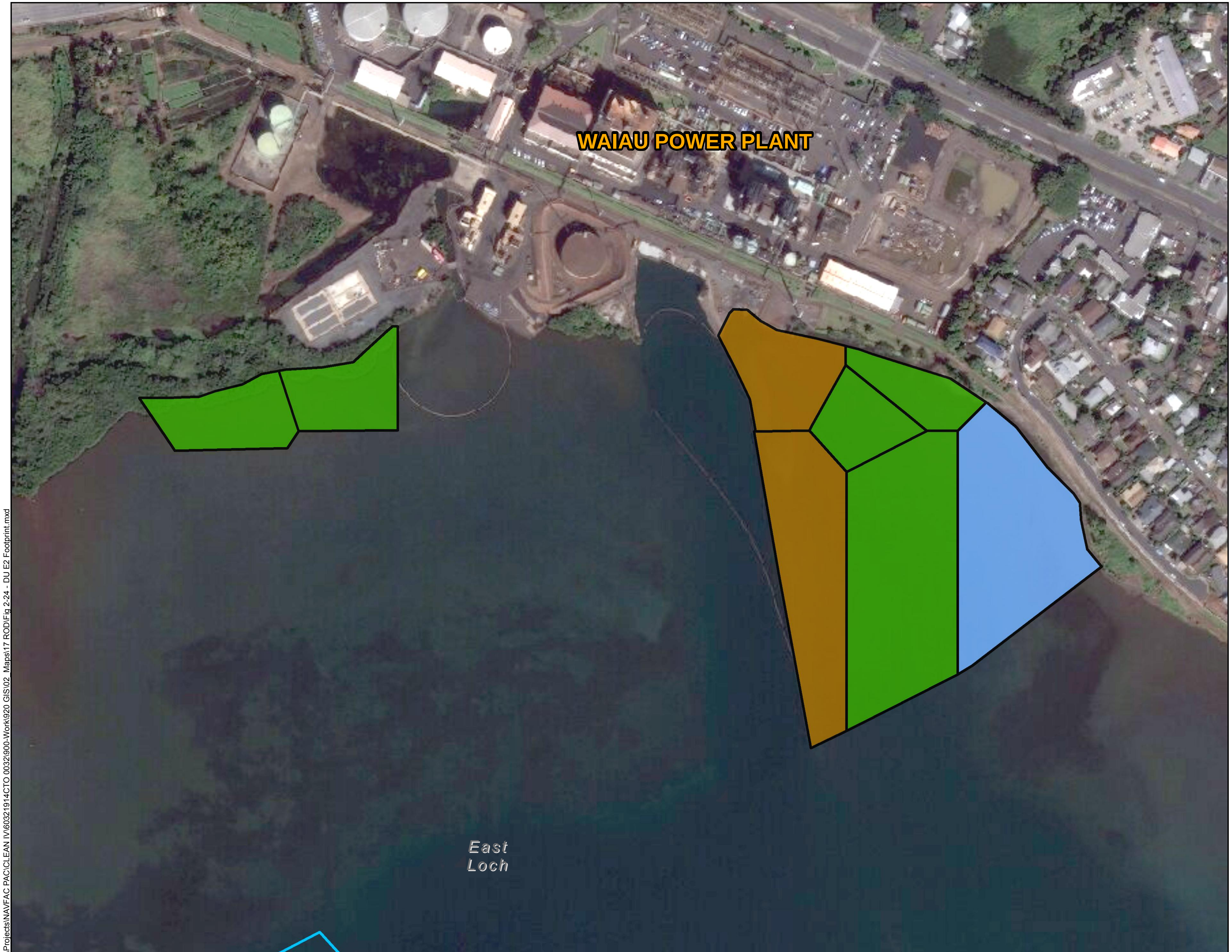
1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. ENR enhanced natural recovery

N

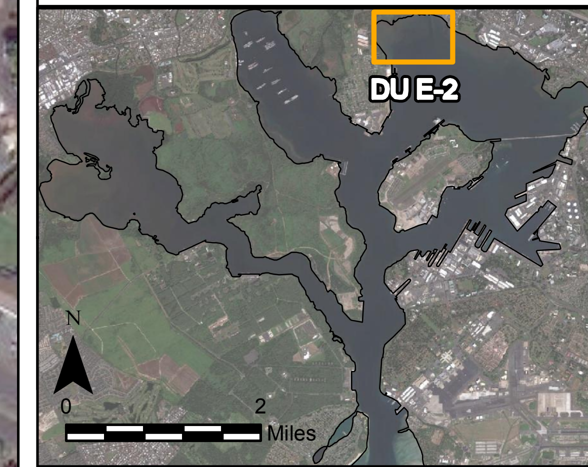
0 125 250 500 Feet

Figure 2-23
DU N-4 Selected Remedial Alternative
Alternative 4 - ENR
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-23 - DU N4 Footprint.mxd



LOCATION MAP



LEGEND

- Maintenance Dredging Footprint
- Dredging Remedy Footprint
- MNR Remedy Footprint
- No Remediation Required Area

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. MNR monitored natural recovery

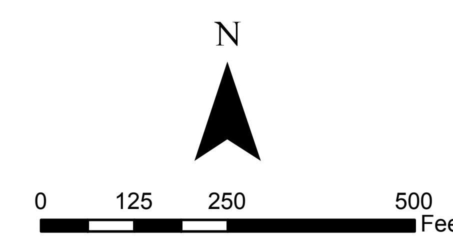
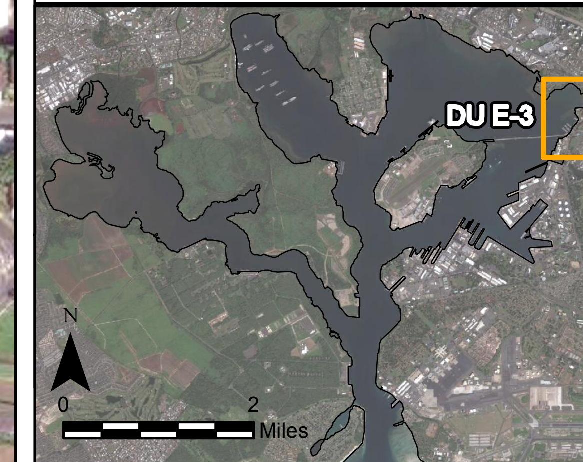


Figure 2-24
DU E-2 Selected Remedial Alternative
Alternative 8 - Focused Dredging with MNR (10 Years)
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-24 - DU E2 Footprint.mxd

LOCATION MAP



LEGEND

- Maintenance Dredging Footprint
- MNR Remedy Footprint
- No Remediation Required Area

NOTES

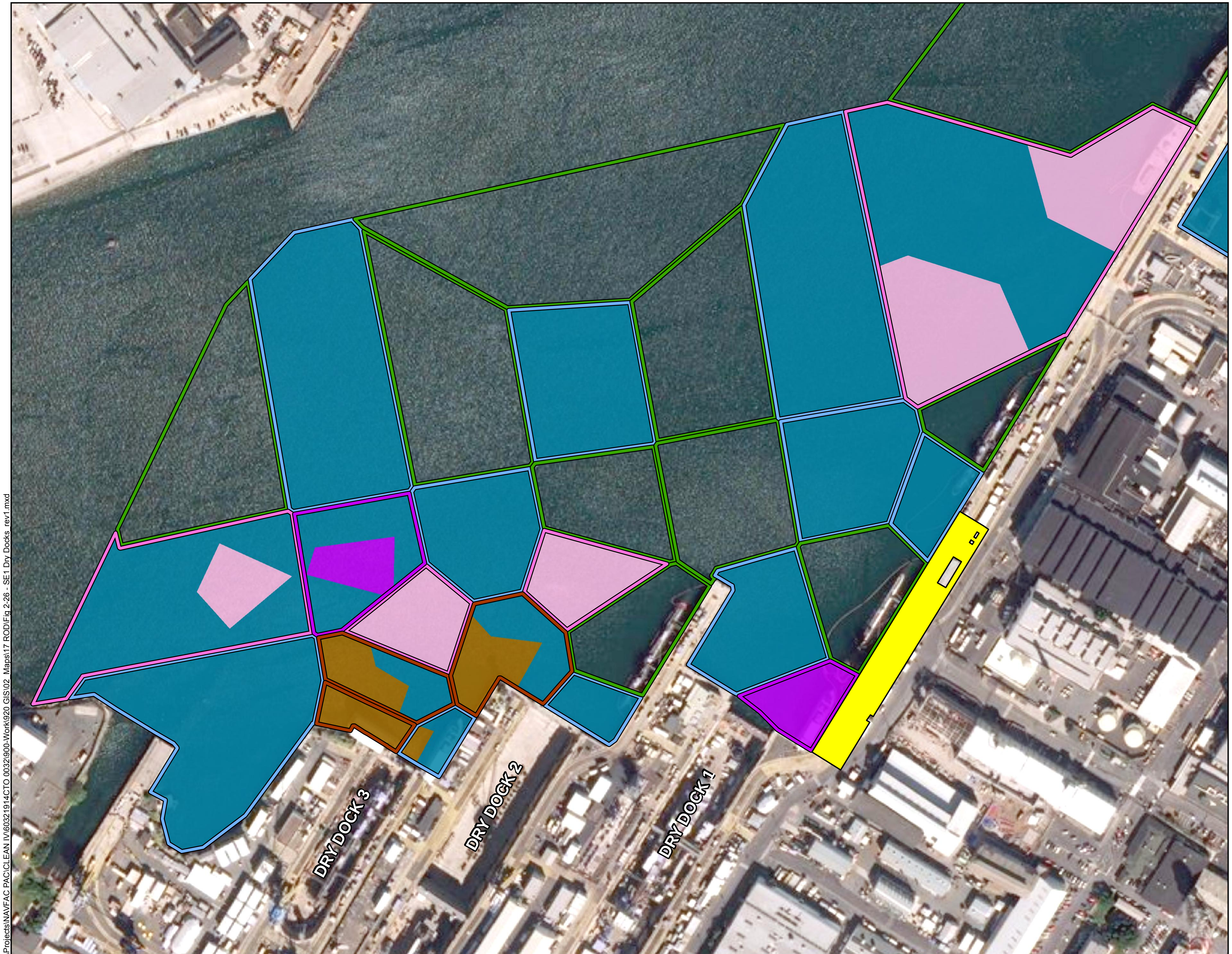
1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. MNR monitored natural recovery

N

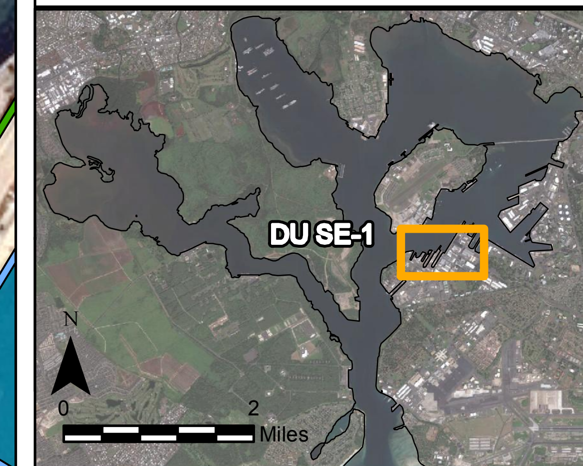
0 250 500 1,000 Feet

Figure 2-25
DU E-3 Selected Remedial Alternative
Alternative 2 - MNR (10 Years)
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914\CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-25 - DU E3 Footprint.mxd



LOCATION MAP



LEGEND

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for Dredging
- Sub-Area Designated for ENR
- Sub-Area Designated for ENR + AC
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy
- Under-pier AC Treatment Area

Refined Remedy Implementation Area

- Dredging Implementation Area
- ENR Implementation Area
- ENR + AC Implementation Area
- MNR Implementation Area

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. AC in-situ activated carbon treatment.
ENR enhanced natural recovery
ENR+AC enhanced natural recovery + AC treatment

N

0 150 300 600
Feet

Figure 2-26
DU SE-1 Dry Docks 1, 2, 3 Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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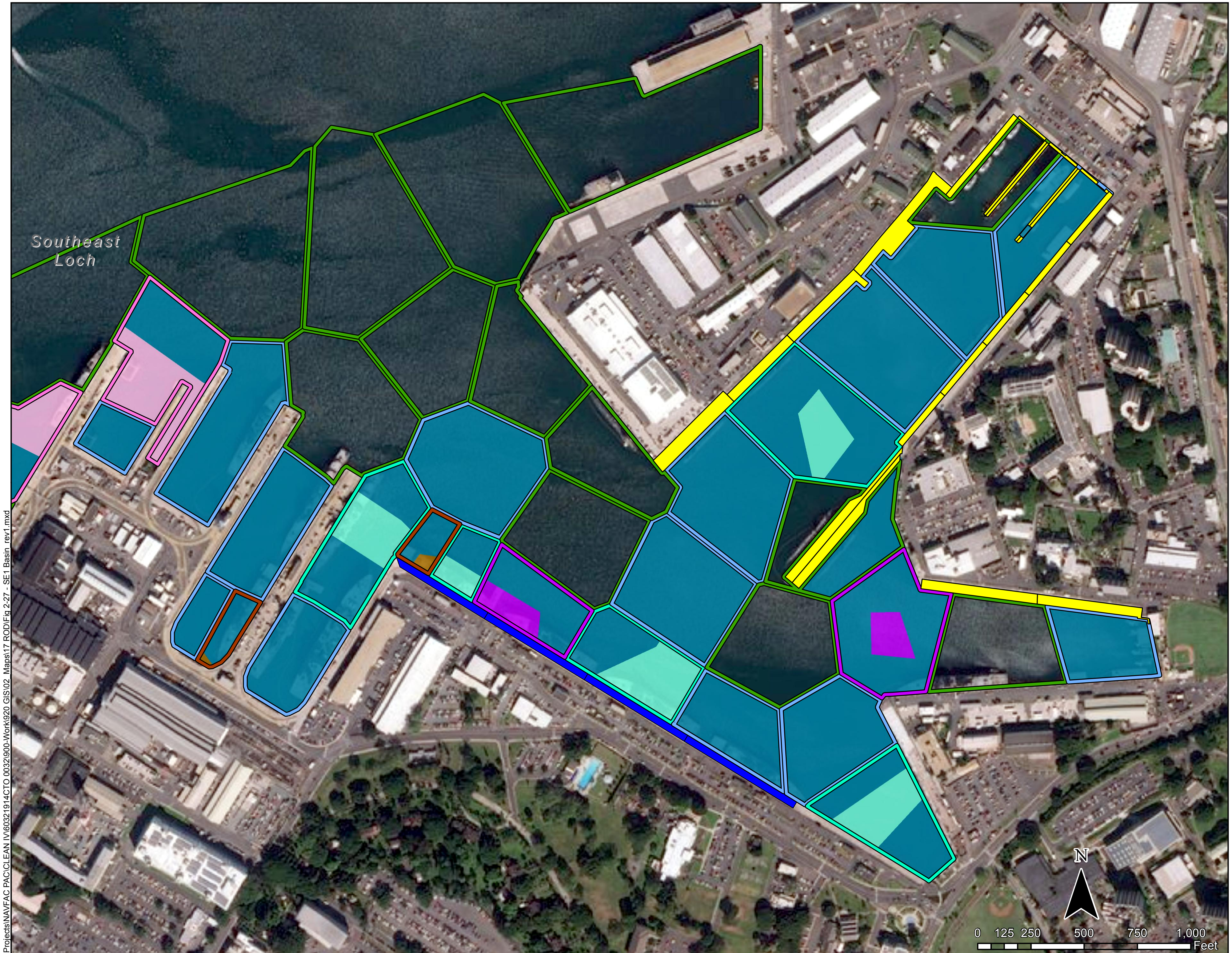
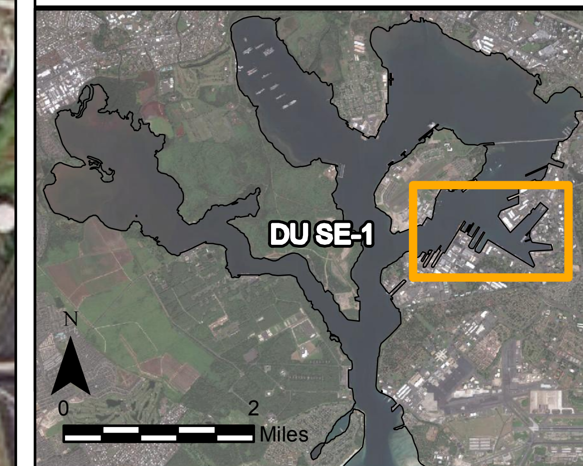


LOCATION MAP



LEGEND

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for Dredging
- Sub-Area Designated for ENR
- Sub-Area Designated for ENR + AC
- Sub-Area Designated for MNR + AC
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy
- Under-pier AC Treatment Area
- Under-pier MNR Area

Refined Remedy Implementation Area

- Dredging Implementation Area
- ENR Implementation Area
- ENR + AC Implementation Area
- MNR + AC Implementation Area
- MNR Implementation Area

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. AC in-situ activated carbon treatment.
   ENR enhanced natural recovery
   ENR+AC enhanced natural recovery + AC treatment
   MNR monitored natural recovery
   MNR+AC monitored natural recovery + AC treatment

Figure 2-27
DU SE-1 Southeast Loch Basin Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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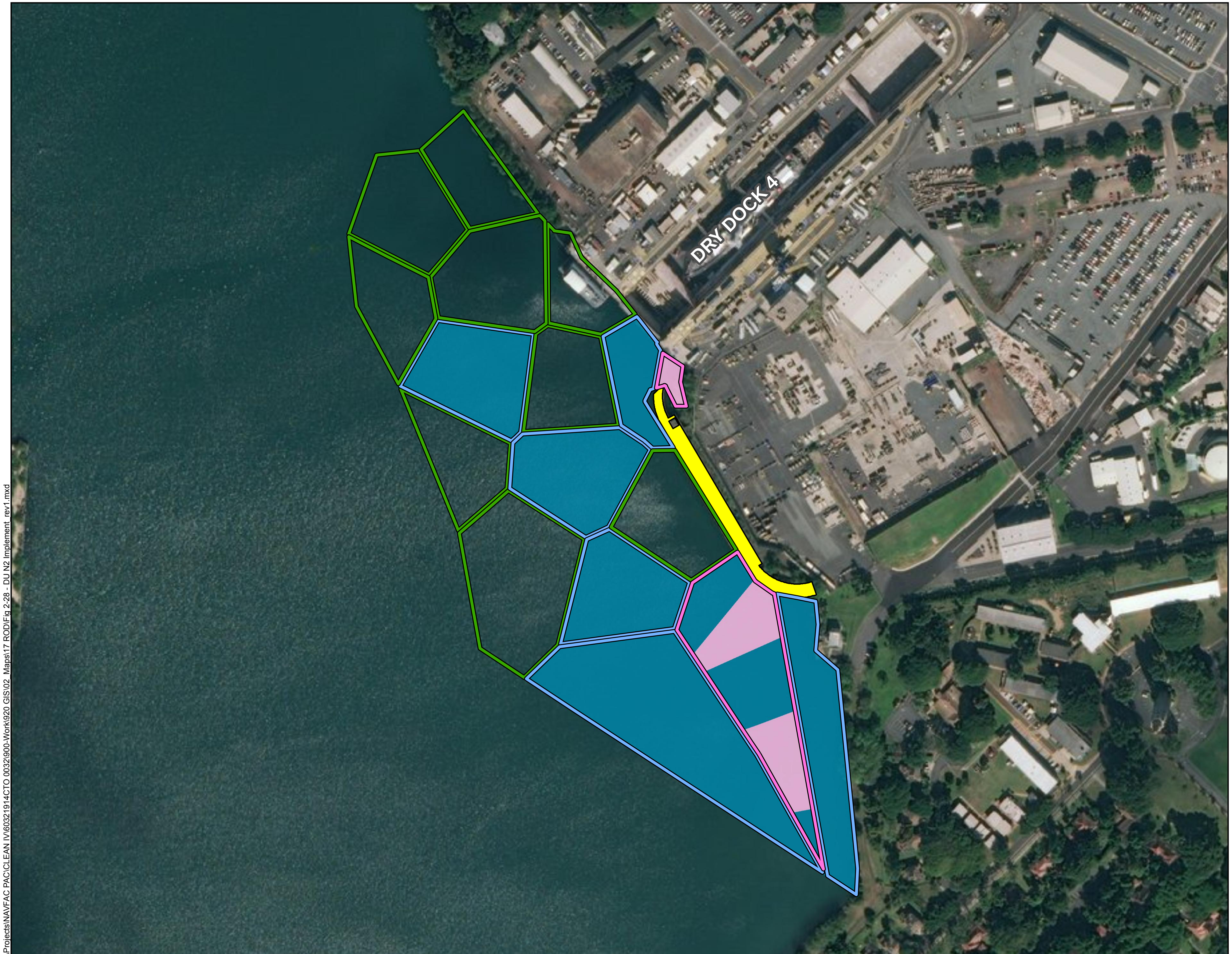
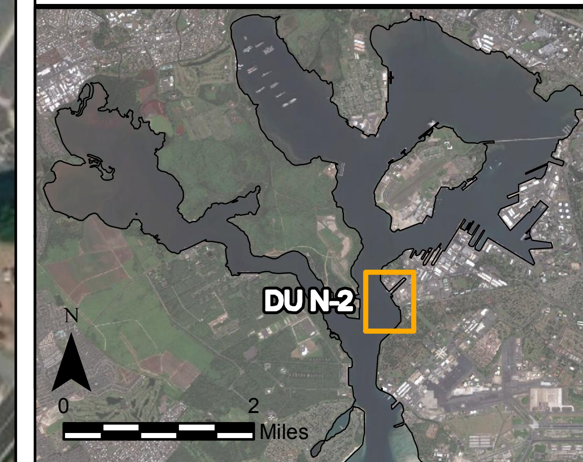


LOCATION MAP



LEGEND

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for ENR
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy
- Under-pier AC Treatment Area

Refined Remedy Implementation Area

- ENR Implementation Area
- MNR Implementation Area

NOTES

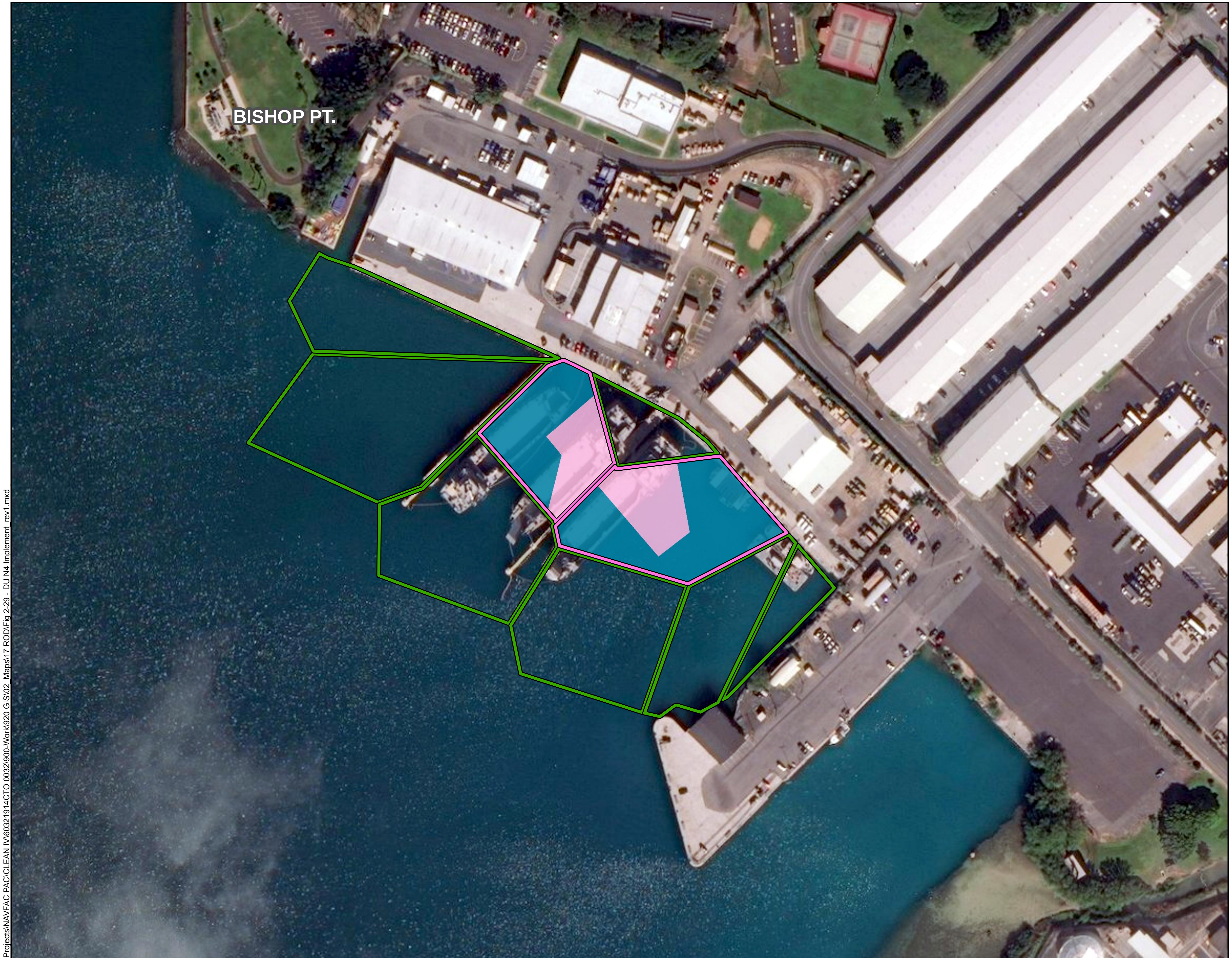
1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 datum (unit: feet).
3. AC in-situ activated carbon treatment.
   ENR enhanced natural recovery
   MNR monitored natural recovery

N

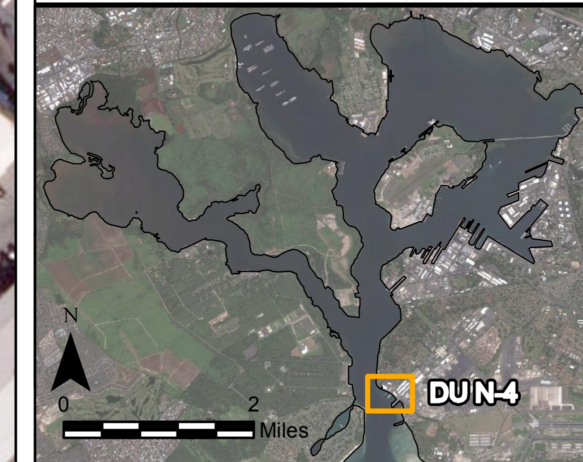
0 150 300 600 Feet

Figure 2-28
DU N-2 Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-28 - DU N2 Implement_rev1.mxd



LOCATION MAP



LEGEND

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for ENR
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy

Refined Remedy Implementation

- ENR Implementation
- MNR Implementation

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. ENR enhanced natural recovery
   MNR monitored natural recovery

N

0 100 200 400 Feet

Figure 2-29
DU N-4 Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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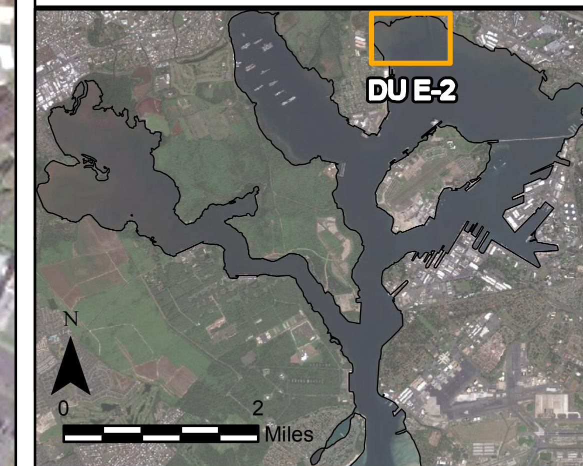
LOCATION MAP



Legend

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for Dredging
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy

Refined Remedy Implementation Area

- Dredging Implementation Area
- MNR Implementation Area

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. MNR monitored natural recovery

N

0 150 300 600 Feet

Figure 2-30
DU E-2 Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig 2-30 - DU E2 Implement_rev1.mxd

3. Responsiveness Summary

A public notice announcing availability for review of the PP was placed in the *Honolulu Star-Advertiser* on January 24, 2016. The public comment period for the PP was initially held between February 1, 2016 and March 1, 2016 and later extended to April 1, 2016. The public meeting for the PP was held on February 10, 2016 at Aiea Elementary School. The Responsiveness Summary provides a summary of the public comments received.

No verbal comments on the PP were received during the public meeting. Responses to the written comments received during the comment period are presented as a Responsiveness Summary in Attachment B within this ROD. The complete transcript of the public meeting is available in the AR file.

3.1 Stakeholder Issues and Lead Agency Responses

The transcript of the public meeting conducted on February 10, 2016 was thoroughly reviewed by the Navy to prepare the Responsiveness Summary. The Navy and EPA, with approval from EPA Headquarters, and with concurrence from the DOH, have selected the remedy for the Pearl Harbor Sediment site only after careful consideration of the public's comments on the PP.

3.2 Technical and Legal Issues

There are no technical and legal issues associated with the selected remedy.

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Attachment A:
Detailed Reference Table

Table A-1: Detailed Reference Table

Item	Reference Phrase in ROD	Location in ROD	Identification of Referenced Document Available in the Administrative Record
1	Initial Assessment Study	Section 2.2.2 Page 2-2	Naval Energy and Environmental Support Activity (NEESA). 1983. *Initial Assessment Study of Pearl Harbor Naval Base, Oahu, Hawaii*. NEESA 13-002. Port Hueneme, CA. October.
2	Pearl Harbor Sediment RI report	Section 2.2.2 Page 2-3	Department of the Navy (DON). 2007. *Remedial Investigation Report, Pearl Harbor Sediment.* Prepared by Earth Tech, Inc. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. April.
3	Pearl Harbor Sediment RI Addendum	Section 2.2.2 Page 2-4	Department of the Navy (DON) 2013. *Remedial Investigation Addendum, Pearl Harbor Sediment, Joint Base Pearl Harbor-Hickam, Hawaii.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Command, Pacific. January.
4	Pearl Harbor Sediment Feasibility Study Investigation	Section 2.2.2 Page 2-4	Department of the Navy (DON). 2015. *Final Feasibility Study, Pearl Harbor Sediment, Joint Base Pearl Harbor-Hickam, Hawaii*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Command, Pacific. June.
5	PP	Section 2.3 Page 2-5	Department of the Navy (DON). 2016. *Proposed Plan, Pearl Harbor Sediment, Joint Base Pearl Harbor-Hickam, Oahu, Hawaii*. JBPHH HI: Naval Facilities Engineering Command, Pacific. February.

Attachment B:
Responsiveness Summary

Table B-1: Responsiveness Summary Table

Comment No.	Comment
HECO, received via email on April 1, 2016	
1a	**Clean up goals in Decision Unit (DU) E-2 should be site-specific and scientifically supportable.** The cleanup goals in DU E-2 (offshore of Hawaiian Electric's Waiau Generating Station) in the upcoming record of decision (ROD) for remediation of Pearl Harbor sediments need to be based on a risk assessment reflecting site-specific data and scientifically accurate conditions in DU E-2. The Proposed Plan states that the DU E-2 sediment preliminary remediation goal (PRG) of 110 micrograms per kilogram (µg/kg) for total polychlorinated biphenyls (PCBs) is based on risks to waterbirds, specifically the Hawaiian stilt (stilt). The PRG was estimated using fish tissue PCB data to estimate risks to wading birds such as the stilt, even though a large part of the stilt's diet consists of invertebrates. Biota-sediment accumulation factors (BSAFs) for invertebrates are lower than those for fish; thus, risks to the stilt were overestimated and the PRG of 110 µg/kg is inappropriate. The use of an overly conservative BSAF resulted in a much lower PRG than would be developed using data for more applicable forage food for the stilt.
Response: The Navy developed the remedial action levels for PCBs in sediments within DU E-2 and the other DUs based on the extensive Pearl Harbor sediment and biota tissue dataset and scientifically supportable site-specific bioaccumulation rates derived from the data. The Navy's recommended remedial action level for DU E-2 has been accepted by both Environmental Protection Agency Region 9 (EPA) and the State of Hawaii Department of Health (DOH) after extensive collaboration and discussion with both regulatory agencies. The sediment PRG for the Hawaiian Stilt was calculated using the same BSAF approach (EPA 2009) as for the fish endpoint. Ecological risk to birds is calculated by estimating a Hazard Quotient (HQ) relating the ingested dose of a contaminant from ingested prey and incidental contact or ingestion of sediment. The concentration of contaminants in prey can be measured directly, or estimated using the BSAF approach. The PRG then becomes the concentration at which the bird is exposed to a HQ=1. For the recalculation of the PRG for the stilt, the same BSAF as was derived for the goatfish was assumed (BSAF=3.9). This BSAF is specific to the Bandtail Goatfish in Pearl Harbor, and is based on the collocated fish/sediment data collected throughout the harbor including DU E-2. Although invertebrates that may serve as a large part of the stilt's diet can potentially have lower BSAFs, fish is also a significant part of the stilt's diet. Therefore, the use of the fish tissue-based BSAFs may be a conservative measure, but is considered appropriate for the project. The Navy has spent significant time and effort to calculate BSAFs for Pearl Harbor in accordance with EPA-recommended methodology, develop PRGs based on the site-specific data, and reach agreement with EPA and DOH on the 110 µg/kg PRG for PCBs in shallow water sediments in Pearl Harbor. The RI Report (DON 2007) and RI Addendum Report (DON 2013) previously proposed a more conservative PRG (29 µg/kg) for PCBs in the shallow areas of Pearl Harbor; however, after evaluating the scientific evidence and the protectiveness, acceptability, and implementability of the site-specific PRGs, the Navy has concluded that the 110 µg/kg value is scientifically defensible and appropriate to ensure protection of human health and the environment.	
1b	Furthermore, the fish samples used to calculate the BSAF were collected throughout Pearl Harbor (5,000 acres surface area), rather than specific to the vicinity of DU E-2 (approximately 121 acres)[1]. PRGs protective of ecological receptors in DU E-2 should be developed in consideration of site-specific conditions within DU E-2, based on site-specific receptors and exposure assumptions and data collected within the vicinity of DU E-2.
Response: The dataset used to calculate the BSAF included data representing fish tissue and sediment samples collected within East Loch region, including the area within and surrounding DU E-2. Given that the home ranges of fish are not limited to the 121-acre area of DU E-2, evaluation of a dataset representing only DU-E-2 will not provide BSAFs that are more representative, predictive, accurate, or protective than the region-wide and harbor-wide BSAFs that have already been established and agreed to by EPA and DOH. The Navy has concluded that significant variability is inherent in the complex biological system that exists in Pearl Harbor; therefore, it is important to evaluate BSAFs using data representing the entire harbor as well as specific regions of the harbor. BSAFs based on data representing the entire harbor were discussed, evaluated, and deemed appropriate for Pearl Harbor by the EPA, DOH, and a National Oceanic and Atmospheric Administration marine expert.	
1c	The Proposed Plan also states that the DU E-2 PRG of 110 µg/kg for total PCBs applies in water depths of 6 ft or less, corresponding to Remedial Action Objective 3 for protection of wading birds that forage in shallow waters in Pearl Harbor. The PRG of 110 µg/kg is based on risks to the stilt (a wading bird); however, the stilt forages in very shallow water (less than 9 in., but prefers depths of less than 5 in.; U.S. Fish and Wildlife Service [USFWS] 2011[2]). Thus, a PRG for wading birds should only apply to very shallow waters (less than 1-ft depth). The Proposed Plan applies the PRG of 110 µg/kg for wading birds across all of DU E-2, even though water depths within DU E-2 extend to greater than 12 ft. according to the Final Feasibility Study (Figure 4-7). PRGs protective of ecological receptors in DU E-2 should be calculated for receptors exposed in both shallow and deep water areas and then applied to those areas of the harbor where exposures may occur.

<table>
<tr><th>Comment No.</th><th>Comment</th></tr>
<tr><td colspan="2">Response: The PRGs selected for each DU are based on the water depths that predominate in that DU. At DU E-2, the extent of the area with water depths less than 2 meters is greater than that of the deeper water area; therefore the PRG for birds that forage within the shallower areas was selected for the entire DU. Additionally, water levels in Pearl Harbor during low-tide conditions are approximately 2 feet below the average water level. The water depth information presented in Figure 4-7 of the Final FS was corrected for tidal influence (i.e., is based on the average water level); therefore, additional areas of shallow water are accessible to the birds during low tide conditions. Furthermore, PCB concentrations in the areas of DU E-2 that is less than 2 meters deep are higher than PCB concentrations in the remainder of DU E-2. Therefore, evaluating the deep areas and the shallow areas separately would likely result in a significantly higher SWAC for the shallow water area (and a lower SWAC for the deep area).</td></tr>
<tr><td>1d</td><td>Hawaiian Electric submitted a memorandum to the Navy, U. S. Environmental Protection Agency (EPA), and Hawaii Department of Health (DOH) on February 12, 2016, outlining a technical approach for conducting a site-specific risk assessment of the types of waterbirds likely to be exposed in the vicinity of DU E-2. This site-specific risk assessment is based on more recent and relevant data (i.e., data for this particular area and relevant to the receptors most likely to be exposed) and was designed to address the limitations of the current cleanup goals as listed above. The proposed approach includes new co-located sediment and benthic invertebrate sampling and analysis, and consideration of actual exposure conditions within the study area, as well as separate evaluations of wading birds and other birds in the deeper water depths associated with DU E-2 (e.g., diving ducks). This analysis should be used to refine the risk estimates and corresponding cleanup levels for DU E-2 to more accurately delineate the remedial footprint (the area requiring remedial action) and support remedial design decisions. Enclosed with this comment letter are two additional planning documents prepared by Hawaiian Electric for the site-specific risk assessment in the vicinity of DU E-2:
• Site-Specific Risk Assessment Work Plan, Pearl Harbor Sediments in the Vicinity of Decision Unit (DU) E-2, Hawaiian Electric Waiau Generating Station.
• Co-Located Sediment and Invertebrate Tissue Sampling and Analysis Plan, Pearl Harbor Sediment in the Vicinity of Decision Unit (DU) E-2, Hawaiian Electric Waiau Generating Station.
Hawaiian Electric will implement the site-specific risk assessment, with additional data collection in May 2016 and completion of the site-specific risk assessment in fall 2016. Hawaiian Electric requests that the Navy incorporate the results of the site-specific risk assessment and revised cleanup levels into the upcoming Pearl Harbor Sediment Remediation ROD.
[1] See study area in vicinity of DU E-2 on Figure 1-2 of attached Site-Specific Risk Assessment Work Plan, Pearl Harbor Sediments in the Vicinity of Decision Unit (DU) E-2.
[2] USFWS. 2011. Recovery Plan for Hawaiian Waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon. Available online at: http://www.fws.gov/pacificislands/CH Rules/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf</td></tr>
<tr><td colspan="2">Response: DU E-2 is part of the integrated Pearl Harbor sediment project because of its geographical location and ecological setting. Although DU E-2 represents only one small portion of Pearl Harbor (~ 3%), the Navy has collected numerous samples from the area within and surrounding DU E-2:
• 18 surface sediment samples and one composite fish tissue sample in 1996
• One 6-foot core sediment sample, one surface composite sediment sample, and two composite fish tissue samples in 2009.
• 17 surface sediment samples in 2012.
The DOH and EPA have agreed that the data are appropriate and sufficient to assess the ecological risks and establish cleanup goals for sediments in DU E-2. The approach taken by the Navy throughout the Pearl Harbor Sediment project has been presented to, discussed with, and approved by both the EPA and DOH at each step of the RI and FS since 2006. Additionally, the evaluation and conclusions for DU E-2 greatly benefited from the results of the overall Pearl Harbor investigation (e.g., BSAF calculations, adjacent terrestrial contaminant sources, sediment transport evaluation results, the local and harbor-wide distribution of sediment contamination, and comparison to the harbor-wide CSM).
The Navy has spent significant time and effort working together with EPA and DOH to develop appropriate and protective cleanup levels for sediments in each DU as required to evaluate and select feasible alternatives for remedial action to reduce risk to human health and the environment to acceptable levels. Revised cleanup levels based on a site-specific risk assessment cannot be incorporated into the ROD without significant discussion with EPA and DOH, as well as the NRRB and CSTAG.</td></tr>
</table>

Comment No.	Comment
2	The Navy's Final Remedy should reflect the current fish tissue concentrations from on-going remedial design investigations which may be below the DOH fish advisory level. Fish tissue monitoring should be used as a measure of ongoing natural recovery and incorporated into the Final Remedy through the adaptive management approach. Because the Final Feasibility Study and recommended remedy for DU E-2 relies significantly on data collected over a long time span (some of which is 20 years old), the Navy should build flexibility into its ROD to allow the incorporation of current data to modify the Final Remedy. This adaptive management approach is recommended by EPA in its sediment remediation guidance 3. The Proposed Plan (Site Background, Page 5, Paragraph 3) references the recommendation from the RI Addendum that several areas of the harbor be subject to long-term fish monitoring, including DU E-2. As discussed on Page 4 of the Proposed Plan, sediment and fish tissue concentrations decreased between the 1996 and 2009 sampling events. The assessment of long-term effectiveness (Page 18, Item 3) discusses the protection of human health and that sediment removal will minimize the need for seafood consumption advisories. For some areas of the harbor, average fish tissue concentrations in 2009 were close to or below the DOH fish advisory level of 190 µg/kg. In 2009, the fish collected in the vicinity of DU E-2 had an average total PCB concentration below the fish tissue threshold of 190 µg/kg. If this trend continues, natural recovery processes should be sufficient to reduce risks for fish consumption to within acceptable levels. The Navy should plan to collect the next round of long-term fish monitoring data, comprehensively in the vicinity of DU E-2 near Hawaiian Electric's Waiau Generating Station, prior to completion of the ROD for Pearl Harbor sediments (currently planned for 2017). It has been 7 years since the last round of tissue data were collected in 2009, and current fish tissue PCB concentrations may indicate that natural recovery is ongoing and, alone, may be the least disruptive and most cost efficient remedy to address PCBs in DU E-2 sediments. [3] USEPA. 2005. Contaminated sediment remediation guidance for hazardous waste sites. EPA-540-R-05-012. OSWER Directive 9355.0-85. December. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

Response: The remedy for DU E-2 is designed to meet the remedial action objectives (RAOs) developed for the site (i.e., ensure protection of human and ecological receptors) by reducing the surface-area-weighted average COC concentrations in surface sediments throughout the DU to protective levels (i.e., the PRGs). The remedy developed for DU E-2 is based on data collected in 2009 and 2012, not 20 year-old data as suggested in the comment (note that the 1996 data were not used for final the PRG and RAL calculations). The RAOs will be achieved when the surface-area-weighted average concentrations of COCs in surface sediments within each DU meet the site-specific sediment PRGs. The Navy intends to conduct additional baseline fish sampling throughout the harbor, including DU E-2, as part of the remedial design process to provide additional data to confirm the fish tissue concentration trends and evaluate the rate of natural recovery. However, even if tissue concentrations continue to decrease, the regulatory agencies will still require the Navy to implement a remedy to address sediments with COC concentrations that could be hazardous to human health and the environment.
No cleanup goals have been established specifically for fish tissue based on the observed decreases in fish tissue concentrations and the low levels indicated by the 2009 data. However, the Navy has agreed with EPA and DOH to compare the fish-tissue COC concentrations to the risk-based fish tissue criteria as an additional measure of remedy effectiveness. Although the RAOs developed for the Pearl Harbor Sediment site do not include lifting the DOH's seafood consumption advisory, the Navy will work with DOH to evaluate the fish tissue concentration data and any additional data that may allow the DOH to remove the seafood consumption advisory for Pearl Harbor.

Comment No.	Comment
3	Need for further evaluation of the Navy's former Waiau drum storage facility as a potential PCB source to sediments in the vicinity of DU E-2. The former Waiau drum storage facility, located on the East Loch of Pearl Harbor, approximately 1,000 ft southeast of the Waiau Generating Station at the current Blaisdell Park, may be a source of contamination to Pearl Harbor sediments in the vicinity of DU E-2. Neither the Final Feasibility Study nor the Proposed Plan addresses the potential for the former Waiau drum storage facility to contribute to sediment contamination in DU E-2. The Navy should conduct additional investigations to assess the former Waiau drum storage facility as a potential PCB source, and evaluate any ongoing risk of re-contaminating Pearl Harbor sediments. The Navy operated a drum storage and cleaning facility at the 26-acre property from 1944 to 1963, when it was sold to the City and County of Honolulu for use as a public park. In 1987, an oil-water separator (OWS) and oil sludge burning pit (OSBP), located within 50 ft of the shoreline, were addressed under the Defense Environmental Restoration Program. The U.S. Army Corps of Engineers (USACE) conducted investigations of these structures and removed them in 1996. The investigations were limited to an approximate 0.5-acre portion of the 26-acre site. During the removal, PCBs were detected in sludge removed from the oil water separator. The presence of PCBs in the OWS sludge indicates the possibility that PCBs may have affected other portions of the site. The USACE's contractor4 reported that “During the approximately 20 years of Navy operations (up until 1963), PCB-impacted waste oils were destroyed at the OSBP.” In 1997, another USACE contractor5 documented the removal of the OWS and OSBP. They identified pipes on the north and south (facing the harbor) ends of the OWS, but did not indicate where the pipes led. The fate of water from the OWS was not discussed; however, based on proximity of the OWS to the shoreline and apparent absence of other waste-related infrastructure such as sanitary sewer lines in this portion of the site, discharge of water (possibly with entrained oil containing PCBs) via a pipe to the harbor is possible. In their report, the USACE contractor recommended: “Perform a detailed review of the site history to assess previous waste handling operations, types of wastes that were stored and when sludge burning activities occurred...Further investigate the 8-inch subsurface pipe to determine its original use and source...Because the site is located within a city park, the potential public health risks to park users and nearby residents should be evaluated.” In 1999, an USACE contractor6 issued a report describing additional investigation work conducted within the 0.5-acre portion of the site (2 percent of the entire facility) containing the OWS and OSBP, including discussion of a baseline risk assessment for dioxins/furans. Hawaiian Electric requested information from the Navy and the USACE to determine if the contractor's recommendations were addressed, and was told there was no additional information. The Navy should evaluate potential PCB impacts to sediments in the harbor adjacent to Blaisdell Park that may have migrated into DU E-2, and assess whether there are ongoing releases that could impact the effectiveness of the Final Remedy. [4] Hawaii International Environmental Services, Inc. 1996. Sampling and analysis plan - Focused site inspection at Neal Blaisdell Park (former Waiau drum storage facility), Pearl City, Hawaii, Project No. H09HI035101. June 18. Kailua, HI. [5] Clayton Environmental Consultants. 1997. Removal of oil sludge burning pit and oil water separator, former Waiau drum storage facility, Neal Blaisdell Park. July 3. Honolulu, HI. [6] Hawaii International Environmental Services, Inc. 1999. Draft report - Additional focused site inspection, Neal Blaisdell Park (former Waiau drum storage facility), Kamehameha Highway, Pearl City, Hawaii. November 9. Kailua, HI.

Comment No.	Comment
Response: The Navy acknowledged the presence of this potential contaminant source at Blaisdell Park during the Remedial Investigation phase. Sediment and biota tissue samples were collected in 1996 and 2009 along the shoreline and offshore of Blaisdell Park and analyzed for chemicals including total PCBs and dioxins/furans (see Figures ES-2, ES-3 and 1-4 of the RI Addendum Report). The data reported for these samples indicated that total PCB and dioxin/furan concentrations in sediment and biota along the shoreline and offshore of Blaisdell Park are below detection limits or well below the project-specific screening criteria. Data from the 1996, 2009, and 2012 investigations indicate that elevated PCB concentrations in DU E-2 sediments are distributed along the shoreline near the power plant, with the highest concentration detected in a sediment sample collected near the power plant's discharge outfall (see Figure 5-22, RI Addendum Report). Data reported for sediment samples collected farther offshore from the power plant indicate lower concentrations of PCBs in surface sediment and no exceedances of the screening criterion. Additional data collected during the FS field investigation in 2012 confirmed the presence of elevated PCB concentrations in sediments near the shoreline, with the highest concentration (4.2 mg/kg) detected in a sediment sample collected directly offshore from the power plant's discharge outfall. Evaluation of the PCB congener profiles indicates that the suite of PCB congeners detected in sediments within DU E-2 is distinctly different from the suite of congeners detected in sediments known to be impacted by Navy and other potential sources of contaminants at Pearl Harbor. Results of the recent sampling conducted by Hawaiian Electric confirm the presence of elevated PCB concentrations in sediments near the power plant's discharge outfall. The Hawaiian Electric investigation also found elevated PCB concentrations in sediments on land upgradient of outlets that extend from the Power Plant property into the harbor. Based on the data and evaluation presented above, the PCB contamination detected in surface sediments within DU E-2 is most likely attributable to releases from the power plant.	
4	The Proposed Plan does not address how ongoing remedial design activities will be incorporated into the ROD. A significant portion of the remedial design is currently ongoing and will be completed prior to the final remedy being selected in the ROD. Performing the remedial design work before a ROD is issued (i.e., before the final remedy determination) may require a portion of the design to be redone (redesigned) if the selected remedy differs substantially from the recommended remedy in the Proposed Plan. The Proposed Plan has limited information about the design and implementation schedule for the recommended remedy. It includes a timeline for the ROD (2016-2017) but does not address the ongoing remedial design work that is being done by the Navy. However, remedial design activities have been ongoing since August 2015, and the 30 percent design is scheduled to be completed in April 2016 and the 60 percent design by December 2017. While the exact date of the ROD issuance is unknown, given the dates listed above, it is possible that a large portion of the design could be completed prior to the ROD being issued. The key sequence of events leading up to a remedial action under CERCLA is defined in the National Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] part 300): • ROD-After completing the Remedial Investigation/Feasibility Study, EPA selects the appropriate cleanup option and publishes it in a public document known as the ROD. • Remedial Design-The remedial design includes the technical analysis and procedures that follow the selection of a remedy for a site. This sequence is also presented in the Department of the Navy Environmental Restoration Program Manual (August 2006): • Remedial Design-This phase involves preparing the detailed design of the remedial action selected in the ROD. Ideally, the Navy should follow the sequence of activities outlined in the NCP to ensure that the remedial design does not need to be modified once the final remedy is selected in the ROD. However, since the remedial design is already under way, the Navy should ensure that the remedial design investigation findings, including newly collected site-specific data from DU E-2, are incorporated into the final remedy, and the final remedy is modified accordingly, as recommended in Comment 2 for supplemental fish tissue concentration findings.

Comment No.	Comment
Response: The Navy is currently preparing a draft basis of design report and a sampling plan for a remedial design field investigation to provide the additional data and information required to complete the remedial design. The Navy has also started to evaluate the draft remedial design in order to ensure that remedy can immediately be emplaced without significant delay after ROD has been finalized. The statement “A significant portion of the remedial design is currently ongoing and will be completed prior to the final remedy being selected in the ROD” is incorrect. The Navy has worked closely with EPA and DOH throughout the FS process to develop and evaluate remedial alternatives. In addition, the preferred remedies described in the FS have been reviewed by the National Remedy Review Board. The preferred alternatives presented in the Proposed Plan were the product of close collaboration with the regulatory agencies, which have indicated that they concur with the recommended alternatives. Therefore, the Navy does not expect that there will be significant changes to the actual remedy selected by EPA, which will be documented in the ROD. Additionally, the comment period for the Proposed Plan has been closed and the only comments received were from HECO. The Navy expects that the preferred remedial alternatives identified in the Proposed Plan will remain as the selected alternatives to be recorded in the ROD. Additional data acquired during the remedial design field investigation will then be used to refine the actual extent of areas to be remediated by the selected technologies, and not to change the actual technologies to be implemented. The Navy is currently evaluating the draft remedial design to ensure that it can be modified if necessary based on the remedial design investigation results.	

References

Environmental Protection Agency, United States (EPA). 2009. *Estimation of Biota Sediment Accumulation Factor (BSAF) from Paired Observations of Chemical Concentrations in Biota and Sediment.* By L. Burkhard, National Health and Environmental Effects Research Laboratory. EPA/600/R-06/047, ERASC-013F. Cincinnati: Office of Research and Development, Ecological Risk Assessment Support Center. February.

Attachment C:
Federal Facility Institutional Control ROD Checklist

EPA Region 9 Federal Facility Institutional Control ROD Checklist for Navy IC RODs

No.	Checklist Item	Location Where Addressed in the Pearl Harbor Sediment ROD
1	Map/Figure showing boundaries of the DUs recommended for remediation.	Figure 1-3.
2	Document risk exposure assumptions and reasonably anticipated land uses, as well as any known prohibited uses which might not be obvious based on the reasonably anticipated land uses. (For example, where “unrestricted industrial” use is anticipated, list prohibited uses such as onsite company day-care centers, recreation areas, etc.).	Section 2.6, Current and Potential Future Land and Resource Uses, page 2-21; and Section 2.5.4, Conceptual Site Model, page 2-12.
3	Describe the risks necessitating the ICs.	Section 2.7.1, Human Health Risk Assessment, page 2-24; and Section 2.7.2, Ecological Risk Assessment, page 2-25.
4	State the IC performance objectives.	Section 2.12.2, Description of the Selected Remedy, page 2-95.
5	Generally describe the IC, the logic for its selection and any related deed restrictions/notifications.	Section 2.12.2, Description of the Selected Remedy,3rd paragraph, pages 2-94 to 2-97; Table 2-13 page 2-42.
6	The following text has been used in place of the standard language: *“Institutional Controls will be maintained until the concentrations of hazardous substances in the sediment are at such levels to allow for unrestricted use and exposure.”*	Section 2.12.2, Description of the Selected Remedy, 4th paragraph, page 2-97.
7	Include language that the Navy is responsible for implementing, maintaining, reporting on, and enforcing the land use controls. This may be modified to include another party should the site-specific circumstances warrant it.	Section 2.12.2, Description of the Selected Remedy, 9th paragraph, page 2-97.
8	Where someone else will or the Navy plans that someone else will ultimately be implementing, maintaining, reporting on, and enforcing land use controls, the following language should be included: *“Although the Navy may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, the Navy shall retain ultimate responsibility for remedy integrity.”*	Section 2.12.2, Description of the Selected Remedy, 10th paragraph, page 2-97.
9	Refer to the remedial design (RD) or remedial action work plan (RAWP) for the implementation actions. Because this is a new idea (i.e., including the IC implementation actions in either or both of these two primary documents), to ensure that the requirement is clear and enforceable, we developed the following language where it makes sense: *“A RA Work Plan will be prepared as the land use component of the Remedial Design. Within 90 days of ROD signature, the Navy shall prepare and submit to EPA for review and approval a RA Work Plan that shall contain implementation and maintenance actions, including periodic inspections.”*	Section 2.12.2, Description of the Selected Remedy, 5th paragraph, page 2-97.

Attachment D:
Pearl Harbor Sediment RI (2007),
RI Addendum (2013), and FS (2015)
(included on CD-ROM)

Attachment E:
Selected Remedy Cost Estimate Spreadsheet

Table E-1: Cost Assumptions

Project Phase	Quantity	Unit	Source	Notes
General Cost Assumptions				
Project Management	6%	percent of construction capital costs	USACE and EPA, July 2000	Project management includes services that are not specific to remedial design, construction management, or technical support of O&M activities. Project management includes planning and reporting, community relations support during construction or O&M, bid or contract administration, permitting (not already provided by the construction or O&M contractor), and legal services outside of institutional controls (e.g., licensing). 6% is higher than the USACE and EPA (2000) guidance due to complexity of the project. This includes agency review and oversight.
Remedial Design	12%	percent of construction capital costs	USACE and EPA, July 2000	Remedial design includes services to design the remedial action. Activities that are part of remedial design include pre-design collection and analysis of field data, engineering survey for design, treatability study (e.g., pilot-scale), and the various design components such as design analysis, plans, specifications, cost estimate, and schedule at the preliminary, intermediate, and final design phases. 12% is higher than the USACE and EPA (2000) guidance due to the complexity of the project.
Construction Management	8%	percent of construction capital costs	USACE and EPA, July 2000	Construction management includes services to manage construction or installation of the remedial action, except any similar services provided as part of regular construction activities. Activities include review of submittals, design modifications, construction observation or oversight, engineering survey for construction, preparation of O&M manual, documentation of quality control/quality assurance, and record drawings. The selected percentage (8%) is higher than the range as specified in the USACE and EPA cost guidance document, due to the complexity of the project.
Scope Contingency	20%	percent of construction capital costs	USACE and EPA, July 2000	Scope contingency is toward the high end specified in the USACE and EPA cost guidance document, because there is likely a large dredging, or "excavation," aspect to the project, which tends to have higher scope contingency based on USACE and EPA guidance.
Bid Contingency	15%	percent of construction capital costs	USACE and EPA, July 2000	Bid contingency of 15% is mid-range of the values specified in the USACE and EPA cost guidance document. Bid contingency is relatively high for aspects of the project with less information, e.g., the conditions and methods for remediating under-pier areas.
Sales Tax	4.0%			State of Hawaii
Discount Rate	2.3%		Office of Management and Budget (OMB) Circular A-94, October 1992	30 year real discount rate for calculating net present value.
Mobilization, Demobilization and Contractor Project Management Costs				
Mobilize/Demobilize Equipment and Facilities (project)	$1,540,000	LS	Assumptions in Table E-2	Includes project management and labor during mobilization and demobilization. These costs would apply once to the entire project, so they are included in DU SE-1 costs only.
Land Lease for Operations and Staging	$0	per year		Assume work is performed on Navy land without additional cost for remediation activities.
Site Office & Operating Expense	$21,600	per month	Assumptions in Table E-2	Includes housing, trailer, boats, travel.
Labor and Supervision	$62,000	per month	Assumptions in Table E-2	Includes superintendent, chief surveyor and quality control management, accountant, certified industrial hygienist, travel, and housing.
Dredging				
Dredge Rate	792	cy *in situ* per day	Assumptions in Table E-3	Assume 2 operations, 1 mechanical and 1 excavator.
Shift Rate	$28,000	per day	Assumptions in Table E-4	Assume 2 operations, 1 mechanical and 1 excavator with 12-hr work shift.
Sediment Handling and Disposal Costs				
Evaporative Dewatering on the barge	$10	per cy	Assumptions in Table E-4	
Water Management	$10,000	per day	Assumptions in Table E-4	Value based on discussions with contractors with local experience and reviewed by Hartman, 2011.
Transload, Transportation and Tipping	$111	per ton	Assumptions in Table E-5	Based on analysis of multiple disposal options in Table E-5.
Material Placement Assumptions				
Debris Sweep	$40,000	per acre	Based on local contractor correspondence	Cost included for reference. Assume that debris sweep would not be necessary because most locations are maintenance dredged and dredging would remove debris. Assume cost includes labor, equipment and survey.
Shift Rate	$14,000	per day	Assumptions in Table E-4	Assume 1 operation, placement by mechanical dredge, with 12-hr work shift.
Cap Placement Rate	1,308	cy per day	Assumptions in Table E-3	Assume 1 operation, at the average rate of one mechanical dredge and one excavator.
ENR/Dredge Residuals Placement Rate	809	cy per day	Assumptions in Table E-3	Assume 1 operation, at the average rate of one mechanical dredge and one excavator.
Under-Pier Thin-layer Cap	$500,000	per acre	Assumptions in Table E-7	Highly uncertain. For costing, assume concrete mat. See Table E-8 other potential options.
Cap/dredge residuals material procurement and delivery (sand)	$82.50	per cy	Assumptions in Table E-6	Cost includes delivery to the site. Based on potential options in Table E-6.
ENR residuals material procurement and delivery (sand with GAC)	$155.85	per cy	Assumptions in Table E-6	Cost includes delivery to the site. Based on potential options in Table E-6.
Activated carbon in-situ treatment (Sedimite)	$142,000	per acre	Assumptions in Table E-6	Cost includes delivery to the site. Based on potential options in Table E-6.

Table E-1: Cost Assumptions (cont'd)

Project Phase	Quantity	Unit	Source	Notes
Construction Monitoring				
Construction Monitoring	$3,486	per day	Vendor quote and BPJ	Construction monitoring includes survey boat, labor and equipment required for routine bathymetric surveys (single beam), data analysis, data delivery, pH/turbidity check, and water quality monitoring. BPJ used to assume daily water quality monitoring described in Table E-8. Additional construction oversight is included in the 10% construction management cost described above.
Post-Construction and Performance Monitoring				
Analytical cost	$675	per sample	Table E-9	
Sampling rate	12	samples/day	Table E-9	Sampling rate for calculating duration of in-water work.
Monitoring daily cost	$7,000	per day	Table E-9	Daily labor, equipment and material costs during performance monitoring.
Data Management Analysis and Reporting	$8,000	per acre	Table E-9	Assume $5,000 for first acre and scale up using power of 0.6.
OM&M Bathymetric survey	$100,000	per 420 acres	Table E-9	Vendor quote - Bathymetry costs calculated by scaling estimated 420-acres cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = Cost(site-wide) * (Area A/420 acres)^0.6.
Post-construction performance monitoring surface sediment sampling density (dredging, capping, ENR)	2	samples/acre	Table E-9	
Post-construction performance monitoring physical sampling density (capping, ENR)	2	samples/acre	Table E-9	Included inspection of physical placement of placement.
Performance monitoring surface sediment sampling density (dredging, capping)	1	samples/acre	Table E-9	
Performance monitoring surface sediment sampling density (ENR, MNR)	2	samples/acre	Table E-9	
O&M monitoring porewater sampling density (capping)	1	samples/acre	Table E-9	
O&M monitoring porewater sampling density (ENR)	2	samples/acre	Table E-9	
O&M monitoring coring sampling density (capping)	1	samples/acre	Table E-9	
O&M monitoring physical sampling density (capping)	1	samples/acre	Table E-9	
O&M monitoring physical sampling density (ENR, MNR)	2	samples/acre	Table E-9	
OM&M Sampling Daily Cost	$7,000	per day	Table E-9	
Cap Repair	$300,000	per acre	Table E-9	Assumed for 5% of the cap area implemented at Year 5 and 10.
ENR Repair	$100,000	per acre	Table E-9	Assumed for 5% of the ENR area implemented at Year 5 and 10.
Area of MNR, ENR, the requires contingency actions	5%			During long-term monitoring, approximately 5% of the total MNR and ENR areas are assumed to require contingency actions. Contingency actions could be ENR, capping, or dredging.
Cost of contingency actions	$100,000	per acre	Table E-9	Assumed for 5% of the MNR and ENR area implemented at Year 5 and 10.
Long-Term Goal Monitoring				
No Active Remediation Areas (DUs N-1, W-1, M-1, and E-1)	$195,116	project	Table E-10	These costs would apply to the entire project, so they are included in DU SE-1 costs only.
DUs Potentially Requiring Active Remediation Areas (DUs SE-1, N-2, N-3, N-4, E-2, E-3)	$359,430	project	Table E-10	These costs would apply to the entire project, so they are included in DU SE-1 costs only.
Institutional Controls				
Institutional Controls	$439,880	net present value for 30 years		Pearl Harbor is a site controlled by the Navy; for security reasons, fishing is allowed only in select locations and only on a catch and release basis. However, some management of ICs (e.g., environmental covenants in capping areas) will require maintenance. For cost estimating and a cost of $20,000 per year is assumed for 30 years to manage fish consumption advisories and environmental covenants. Other ICs (e.g., ICs during construction), are assumed to be incorporated into other costs (e.g., construction costs). These costs would apply to the entire project, so they are included in DU SE-1 costs only.
Dredge Volume				
Dredge prism volume factor	1.5			This factor is multiplied by the volume of contaminated sediment in GIS, for constructability (e.g., stable side slopes), overdredging, and volume contingencies (e.g., horizontal and vertical delineation).

Table E-2: Mobilization, Demobilization, and Contractor Project Management Costs

Mobilization/Demobilization

Item	Number of Operations	Cost per Operation	Notes
Mechanical Dredging Operation	1	$150,000	*A clamshell dredge with multiple buckets and a crew of 5 people *A support/tender barge for managing the anchors with a crew of 3 people *An assist tug for maneuvering the dredge with a crew of 4 people *Two (2) material barges for short-term storage of dredged sediments
Excavator Dredging Operation	1	$150,000	*A large size (~30 ton) excavator with multiple buckets placed on a spud barge with a crew of 4 people *An assist tug for maneuvering the spud barge with a crew of 4 people *Two (2) material barges for short-term storage of dredged sediments
Mechanical Placement Operation	1	$150,000	Same as mechanical dredging operation above
Under-Pier Placement Operation	1	$75,000	*Construction equipment based on placement of grout mat placement or pump in place concrete mat: *Construction equipment for grout mat placement or pump in place concrete mat including a mix truck and pump truck placed on the upland with a crew of 4 people *Vessel for diver-support and crew of 4 people *Material barge for staging mats for placement with a crew of 4 people *Work skiff for positioning materials under the pier
Survey Boat	1	$5,000	
Staging Area and Construction Office	1	$5,000	Assume costs are minimized based on use of Navy land.
Haul Barges	8	$10,000	
Barge Protection	1	$80,000	Barge protection is necessary to mitigate wear to barges during dredging operations.
Construction Work Plan	1	$75,000	
Subtotal for a single mobilization		**$770,000**	
Subtotal for mobilization/ demobilization		**$1,540,000**	Contractor correspondence indicated that mobilization for a single operation is between $1 and $3 million depending on the location. This cost estimate assumes some economy of scale for mobilizing multiple operations.

Project Management and Operations

Item	Cost	Unit	Notes
Land Lease for Operations and Staging	$0	per year	Assuming that Navy land will be used for staging at no additional project costs. Preliminary estimate suggests 2 acres minimum necessary.
Site Office & Operating Expense	$22,000	per month	Includes housing, trailer, boats, travel.
Labor and Supervision	$62,000	per month	Includes project manager, chief surveyor and quality manager, works manager or superintendent, surveyor, accountant, certified industrial hygienist/ health and safety.

Table E-3: Production Rate Estimates

Dredging

Parameter	Mechanical Dredging	Excavator Dredging	Unit
12-hr Operation			
Cycle Time	3.5	3	min
Bucket Capacity	6	5	cy
Bucket Fill at 55% [a]	3.3	2.8	cy
Bucket Fill at 40% - Debris Sweep	2.4	2	cy
Operating Day	12	12	hrs/day
Effective Working Time [b]	60%	60%	cy/day
Daily Dredge Production	407	396	cy/day
Daily Dredge Production - Debris Sweep	296	288	cy/day
Combined Dredge Production (5% debris sweep, 95% without debris sweep)	402	391	cy/day
Combined Dredge Production (at 1.5 tons/cy)	603	586	tons/day

Capping

Parameter	Mechanical Placement	Excavator Placement	Unit
Cycle Time	2.5	2	min
Bucket Capacity	8	5	cy
Bucket Fill Factor (85%)	6.8	4.25	cy
Operating Day	12	12	hrs
Effective Working Time	75%	75%	
Daily Production	1,469	1,148	cy/day

Thin-Layer Placement (ENR, dredge residuals, under-pier thin-layer capping)

Parameter	Mechanical Placement	Excavator Placement	Unit
Cycle Time	4.5	2.5	min
Bucket Capacity	8	5	cy
Bucket Fill Factor (85%)	6.8	4.25	cy
Operating Day	12	12	hrs
Effective Working Time	70%	70%	
Daily Production	762	857	cy/day

[a] USACE 2008. Technical Guidelines for Environmental Dredging of Contaminated Sediments. ERDC/EL TR-08-29.

[b] ibid. Operating efficiency includes allowance for non-production activities such as equipment maintenance/repair, water quality management, navigation systems, agency inspections, waiting for test results, moving dredges/barges, traffic, standby for navigation and refueling.

Table E-4: Daily Rates

Daily Rate for a Single Operation (Dredging or Placement)

Item	Cost	Unit	Notes
12-hr Operation			
Labor	$6,000	per day	For a single operation, includes superintendent, foreman, operator, deck hands, and boat operator.
Equipment	$8,000	per day	For a single operation, including barge with dredge, tug, and material barges.
Total	**$14,000**	**per day**	Assume economy of scale will be achieved with multiple operations (up to 4) that might occur simultaneously.

Water Management for Dredged Material

Item	Cost	Unit	Notes
Water Management	$10,000	per day	Water management cost typical for relatively large-scale remediation projects. Assume water is discharged back into Pearl Harbor.
Evaporative Dewatering	$10	per cy	Cost estimated at $10 per cubic yard ($7 per ton) based on Navy and local contractor correspondence for barge transportation of sediments to transloading facility.

Table E-5: Disposal Options

Disposal Option	Unit Cost or Quantity	Unit	Notes
Upland Disposal (Hawaii)			
Transloading mobilization, construction and handling	$30	per cy	Local contractor Healy Tibbetts approximates $25-$30 cy for loading and hauling.
Transport to and Tipping at Landfill	$200	per ton	Assume solid CERCLA-regulated non-hazardous material. Cost from Pacific Commercial Services.
Subtotal	**$220**	**per ton**	
Open-Water Disposal in the South Oahu Ocean Dredged Material Disposal Site (SOODMDS) for material that passes criteria			
Transport and Disposal of Material at Open Water Disposal Site	**$10**	**per ton**	Cost estimated at $10-$15 per cubic yard ($7-$10 per ton) based on Navy and local contractor correspondence.
Construction of Confined Aquatic Disposal (CAD) in Pearl Harbor			
Mob/Demob	$0		Assume construction of CAD cell does not require additional mobilization; the same set of equipment is used to construct the CAD cell as for the remediation.
Transport and Disposal of Material at CAD	$15	per cy	Cost estimated at $10-$15 per cubic yard ($7-$10 per ton) based on Navy and local contractor correspondence.
Overburden Removal Rate from CAD Cell (mechanical dredging operation)	1,344	cy *in situ* per day	Assume 10 cy bucket at 3 minutes per cycle, 70% fill and 80% operation time for 12 hour day.
Impacted Material/Clean Cap Material Placement Rate (mechanical placement operation)	1,469	cy per day	Based on Table E-6. Split-hull barge would speed operations.
Volume of overburden removal	950,000	cy *in situ*	USACE 2000. Long-Term Management Strategy for Dredged Material Disposal for Naval Facilities at Pearl Harbor, Hawaii. Phase I – Formulation of Preferred Disposal and Management Alternatives. USACE Engineer Research and Development Center (ERDC).
Volume of contaminated sediment placed	870,000	cy bulked sediment	Represents 725,000 cy of *in situ* contaminated sediment with a bulking factor of 1.2. 725,000 cy represents the mid-range of the alternatives.
Volume of capping material	71,000	cy	Assuming a diameter of 900 ft (15 acres) (USACE 2000).
Capping material cost	$150	per cy	Table E-6
Total construction time assuming 3 operations	449	days	Includes removal of clean material, placement of contaminated material, and capping.
Dredging or placement daily rate	$14,000	per day per operation	Table E-4
Subtotal construction	**$31,915,060**		
Subtotal disposal of overburden in open-water facility	**$14,250,000**		
Subtotal capping material cost	**$10,650,000**		
Subtotal construction and (long-term) performance monitoring and maintenance cost	**$9,624,000**		Based on the assumptions for capping in Tables G-9 and G-10 assuming 30 years of monitoring and maintenance.
Total cost	$66,439,060		
Cost per ton of contaminated sediment	**$61**	**per ton**	Design is assumed to be incorporated into general cost assumption percentages in Table E-1.
Construction of an Upland Confined Disposal Facility (CDF)			
Mob/Demob	$10,000		The construction equipment operation is assumed to include: 1) one medium size (~20 ton) articulating front-end loader for constructing the perimeter berm and moving material, 2) two medium size (~20 ton) bulldozers for constructing the perimeter berm and moving material, 3) equipment for liner placement and 4) equipment for hauling and moving contaminated sediment.
Clearing and grubbing	$5,000	per acre	Includes equipment, labor, disposal for 90 acres, assuming heavily vegetated area.
Subtotal mobilization, clearing and grubbing	**$460,000**		
Overburden removal and berm construction rate	3,000	cy *in situ* per day	
Volume of berm material	61,000	cy *in situ*	Assume 10 ft tall, 12 ft wide at the top and sloped at 3 to 1.
Berm construction time assuming one operation	20	days	
Excavate and Stockpile Material	$6	per cy	Previous projects
Berm Construction	$4	per cy	Previous projects
Impermeable liner and Leachate Collection System	$120,000	per acre	Includes material (clay liner, 60-mil HDPE and geotextile), leachate collection system, equipment, labor, installation for 90 acres.
	$35,000	per acre	Includes labor, material and equipment for drainage layer and collection sumps below the liner.
Subtotal berm and liner construction cost	**$14,560,000**		
Volume of contaminated sediment placed	870,000	cy bulked sediment	Represents 725,000 cy of *in situ* contaminated sediment with a bulking factor of 1.2. 725,000 cy represents the mid-range of the alternatives.
Transportation, transloading and contaminated sediment placement	$30	per cy	Local contractor Healy Tibbetts approximates $25-$30 cy for loading and hauling.
Subtotal transportation, transloading and contaminated sediment placement	**$26,100,000**		
Cover System and Site restoration (e.g., planting)	$100,000	per acre	Includes topsoil, rooting zone soil, drainage layer, impermeable line, and vent layer.
Subtotal cover system and site restoration	**$9,000,000**		
Subtotal 30-year monitoring cost	**$6,598,197**		Assume $300,000 per year for 30 years.
Total cost	**$56,718,197**		
Cost per ton of contaminated sediment	**$52**	**per ton**	Design, monitoring, operations and maintenance are assumed to be incorporated into general cost assumption percentages in Table E-1.
Barge to Mainland with Upland Disposal (Disposal option not used in cost estimate - shown for informational purposes)			
Transload, truck transport to, and tipping at Subtitle D Landfill on U.S. mainland	$90	per ton	Cost includes material transfer from barge onto offloading area, load dewatered sediment onto truck with containers, truck to disposal facility. Local contractor Healy Tibbetts approximates $25–$30 cy for loading and hauling. Assume two haulings (one from the transloading facility to the container terminal in Hawaii and then one from U.S. mainland container facility to the landfill).
Barge material to/from U.S. mainland	$450	per ton	Healy Tibbetts estimate suggests $450 per ton for container shipping. Pacific Commercial Services LLC suggests a cost between $450 and $2,000 per ton depending on contaminants. Select $450 per ton to assume some economy of scale.
Subtotal	**$540**	**per ton**	Based on public bids on Oahu's garbage, the cost to ship and dispose of garbage is $100 to $200 per ton.

Table E-5: Disposal Options

Disposal Option	Unit Cost or Quantity	Unit	Notes
Treatment by Soil Washing, Mechanical Dewatering & Water Trmt (Disposal option not used in cost estimate - shown for informational purposes)			
Mob/Demob, Site Layout, Land Leasing Costs	$4,000,000	LS	ART Engineering, LLC., Tampa FL. Includes capital cost from conception to production, total plant footprint of approximately 4–7 acres with 40–45 tons per hour capacity.
Soil Washing, Mech Dewatering, Water Trmt, disposal of fine fraction	$120	per cy	ART Engineering, LLC., Tampa FL. Assume 50% sand treated sand and 50% remaining fines. Cost includes labor, plant operations, maintenance fine fraction, disposal of remaining fine fraction at Subtitle D landfill, and no credit for beneficial reuse of sand.
Assumed % Sand Fraction by Mass	50%		This a high estimate.
Clean Sand Fraction Disposal	$0	per cy	Assume no credit for beneficial reuse of sand. Treated sand may have a disposal cost.
Contaminated Fine Fraction Disposal	$61	per ton	Based on CAD construction above.
Subtotal	**$214**	**per ton**	
Summary: Transloading, shipment, and disposal costs used in cost estimate			
Best estimate	**$111**	**per ton**	Average of upland disposal, CAD, and CDF.
Low estimate	**$57**	**per ton**	Average of CAD and CDF costs.
High estimate	**$220**	**per ton**	Upland disposal.

Table E-6: Material Procurement Unit Costs

Sand (8/30 Sieved)

Item	Cost	Unit	Cost	Unit	Notes
Base cost	$90.00	per ton	$135.00	per cy	Ameron Hawaii price schedule. Manufactured sand with a more narrow range of grain (e.g., coarse sand) size is approximately $65 - $90 per ton. Cost ranges approximately $30 - $40 per ton for Grade A and Grade B stone specifications.
Delivery	$10.00	per ton	$15.00	per cy	B&C trucking quote.
Total	**$100.00**	**per ton**	**$150.00**	**per cy**	

Stone (4–8 inch) (for reference only)

Item	Cost	Unit	Cost	Unit	Notes
Base cost	$51.05	per ton	$76.58	per cy	Ameron Hawaii price schedule.
Delivery	$10.00	per ton	$15.00	per cy	B&C trucking quote.
Total	**$61.05**	**per ton**	**$91.58**	**per cy**	

Reuse Dredged Sediment from CAD Construction or Maintenance Dredging Outside of Contaminated Footprint

Item	Cost	Unit	Cost	Unit	Notes
Handling and Delivery	$10.00	per ton	$15.00	per cy	Estimated based on other local costs.
Total	**$10.00**	**per ton**	**$15.00**	**per cy**	

Granular Activated Carbon (GAC) Amended Sand

Item	Cost	Unit	Cost	Unit	Notes
GAC (delivered)	$1.25	per lb			Luthy et al. 2009 ($1.07 per lb with ~ 25% premium for Hawaii).
GAC (delivered)	$2,500.00	per ton	$3,750.00	per cy	
Mixing percentage (% by mass GAC/sand)	4%				Typical for remediation of other sites.
Total GAC Amended Reused Dredge Material	**$109.60**	**per ton**	**$164.40**	**per cy**	
Total GAC Amended Sand	**$196.00**	**per ton**	**$294.00**	**per cy**	

Summary: Capping and Dredge Residuals Costs for Cost Estimate

Item	Cost	Unit	Cost	Unit	Notes
Best estimate	$55.00	per ton	$82.50	per cy	Assume 50% upland and 50% reused dredge material.
Low estimate	$10.00	per ton	$15.00	per cy	Assume reused dredge material.
High estimate	$100.00	per ton	$150.00	per cy	Assume upland material.

Summary: ENR Costs for Cost Estimate

Item	Cost	Unit	Cost	Unit	Notes
Best estimate	$103.90	per ton	$155.85	per cy	Assume 50% ENR and 50% in-situ; base material assume 50% upland and 50% reused dredge material.
Low estimate	$59.80	per ton	$89.70	per cy	Assume 50% ENR and 50% in-situ; base material reused dredge material.
High estimate	$148.00	per ton	$222.00	per cy	Assume 50% ENR and 50% in-situ; base material upland material.

Summary: AC Amendment Costs for Cost Estimate

Item	Cost	Unit	Notes
Best estimate	$142,000	per acre	Based on 1.25% AC added to sediment, cost for material and shipping only; SediMite cost estimated at $2.25 / pound (assume 25% reduction from TS cost for large scale application)
Low estimate	$113,500	per acre	Based on 1.0% AC added to sediment; cost for material and shipping only; SediMite cost estimated at $2.25 / pound (assume 25% reduction from TS cost for large scale application)
High estimate	$284,000	per acre	Based on 2.5% AC added to sediment; cost for material and shipping only; SediMite cost estimated at $2.25 / pound (assume 25% reduction from TS cost for large scale application)

Table E-7: Under-Pier Remediation

Method #1: Thin-Layer Sand Placement

Parameter	Value	Unit	Notes
Daily Production Rate	100	cy/day	Approximately 1/10 of excavator open-water placement.
Sand cost	$150.0	per cy	Table E-6
Cap thickness	1	ft	
Placement volume	2420	cy per acre	Assuming 1.5 ft placement to achieve 1 ft minimum everywhere.
Daily Cost	$14,000	per day	Table E-4
Subtotal material cost per acre	$363,000	per acre	
Subtotal labor and equipment cost per acre	$338,800	per acre	
Total cost per acre	**$701,800**	**per acre**	

Method #2: Thin-Layer Augmented Material Placement

Parameter	Value	Unit	Notes
Daily Production Rate	100	cy/day	Approximately 1/10 of excavator open-water placement.
Augmented material cost	$1,150	per cy	Based on quote from AquaBlok®.
Cap thickness	1	ft	
Placement volume assuming 1.5-ft placement to achieve 1 ft minimum everywhere	2420	cy per acre	Assuming 1.5 ft placement to achieve 1 ft minimum everywhere.
Daily Cost	$14,000	per day	Table E-4
Subtotal material cost per acre	$2,783,000	per acre	
Subtotal labor and equipment cost per acre	$338,800	per acre	
Total cost per acre	**$3,121,800**	**per acre**	

Method #3: Armorflex or Pump in Place Concrete Mats

Parameter	Value	Unit	Notes
Total cost per acre	**$500,000**	**per acre**	Local contractor quote assuming upland construction. Equipment includes a concrete pump, work skiff, crane, support barge, and dive crew with support vessel.

Method #4: Aquagate+PAC

Subtotal material cost per acre	$490,050	per acre	Based on calculation from the Under-Pier Treatability Study (AECOM 2014)
Subtotal labor and equipment cost per acre	$338,800	per acre	Table E-4
Total Cost per acre	**$828,850**	**per acre**	

Method #5: Sedimite

Subtotal material cost per acre	$326,700	per acre	Based on calculation from the Under-Pier Treatability Study (AECOM 2014)
Subtotal labor and equipment cost per acre	$338,800	per acre	Table E-4
Total Cost per acre	**$665,500**	**per acre**	

Cost Used in Cost Estimate

Parameter	Value	Unit	Notes
Best-estimate	**$500,000**	**per acre**	Assume pump in place concrete mats as the preliminary remedy.

Table E-8: Construction Monitoring

Multi-Beam Survey Inclusive of Acquisition, Processing, and Data Delivery	Cost	Unit
Quote 1	$ 4,780	per survey
Quote 2	$ 5,075	per survey
Average of 2 quotes	$ 4,928	per survey
Assume 1 survey per 5-day work week	$ 985.50	average per construction day

Water Quality Sampling during Construction	Cost	Unit
Analytical cost	$ 1,000	per sample
Labor, equipment and materials cost	$ 1,500	per sample
Assume one sample per day	$ 2,500	average per construction day

Total Construction Monitoring Daily Rate	$ 3,486	per day

Notes:

1. Multi-beam survey cost includes equipment and labor to collect bathymetric survey data, data processing and delivery, and labor/equipment to collect and document pH/turbidity data.

2. Water quality sampling costs assume four monitoring stations: three for the dredging event that occurs in deep water and one for the dredge that operates in shallow water close to the banks; one sampling event for every station every day during construction. The number of samples that will require chemical analysis for PCBs and other COCs is assumed to be 25% of the field screening samples (one per day).

3. Total construction monitoring includes survey boat, labor and equipment required for routine bathymetric surveys (single beam), data analysis, data delivery, pH/turbidity check, and water quality monitoring. Additional construction oversight is included in the construction management % cost described in Table E-1.

Table E-9: Performance Monitoring

Remedial Alternative	SE-1 Alt 13: Focused Dredging with ENR, AC, and MNR (20 Years)	N-2 Alt 10: ENR with MNR (10 Years)	N-3 Alt 4: ENR	N-4 Alt 4: ENR	E-2 Alt 8: Focused Dredging with MNR (10 Years)	E-3 Alt 2: MNR (10 Years)
Post-Construction Performance Monitoring						
Dredge						
Analytical cost per sample (note 1)	$675	$675	$675	$675	$675	$675
No. of chemical surface samples per acre	2	2	2	2	2	2
Remediation area (acres)	2	0	0	0	2	0
Daily labor, equipment, materials daily rate (note 2)	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
No. of monitoring days (note 3)	0	-	-	-	0	-
Bathymetry (note 4)	$4,067	$0	$0	$0	$3,415	$0
Subtotal analytical cost (note 5)	$2,727	$0	$0	$0	$2,039	$0
Subtotal labor, equipment, bathymetry and materials cost	$6,424	$0	$0	$0	$5,177	$0
Data management, analysis and reporting (note 6)	$12,198	$0	$0	$0	$10,244	$0
Total monitoring cost for Post-Construction Event	**$21,349**	**$0**	**$0**	**$0**	**$17,460**	**$0**
ENR						
Analytical cost per sample (note 1)	$675	$675	$675	$675	$675	$675
No. of chemical surface samples per acre	2	2	2	2	2	2
No. of locations for physical testing/inspection per acre	2	2	2	2	2	2
Remediation area (acres)	12.6	1.6	0.6	0.7	0.0	0.0
Daily labor, equipment, materials (note 2)	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
No. of monitoring days (note 3)	2	0	0	0	-	-
Bathymetry (note 4)	$12,198	$3,536	$1,963	$2,153	$0	$0
Subtotal analytical cost (note 5)	$17,010	$2,160	$810	$945	$0	$0
Subtotal labor, equipment, bathymetry and materials cost	$26,898	$5,403	$2,663	$2,970	$0	$0
Data management, analysis and reporting (note 6)	$36,586	$10,606	$5,888	$6,459	$0	$0
Total monitoring cost for Post-Construction Event	**$80,493**	**$18,169**	**$9,361**	**$10,374**	**$0**	**$0**
Performance Monitoring						
Dredge						
Analytical cost per sample (note 1)	$675	$675	$675	$675	$675	$675
No. of surface sediment samples per acre	1	1	1	1	1	1
No. of porewater samples per acre	0	0	0	0	0	0
No. of cores per acre	0	0	0	0	0	0
No. of samples for physical testing per acre	0	0	0	0	0	0
Remediation area (acre)	2.0	0.0	0.0	0.0	1.5	0.0
Daily labor, equipment, materials (note 2)	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
No. of monitoring days (note 3)	0	-	-	-	0	-
Bathymetry (note 4)	$4,067	$0	$0	$0	$3,415	$0
Subtotal per event analytical cost (note 5)	$1,364	$0	$0	$0	$1,019	$0
Subtotal per event labor, equipment and materials cost	$5,245	$0	$0	$0	$4,296	$0
Data management, analysis and reporting (note 6)	$12,198	$0	$0	$0	$10,244	$0
Total monitoring costs per event	$18,807	$0	$0	$0	$15,560	$0
Total monitoring cost NPV assuming years 2,5	**$34,757**	**$0**	**$0**	**$0**	**$28,755**	**$0**
Cap						
Analytical cost per sample (note 1)	$675	$675	$675	$675	$675	$675
No. of surface sediment samples per acre	1	1	1	1	1	1
No. of porewater samples per acre	1	1	1	1	1	1
No. of cores per acre	1	1	1	1	1	1
No. of samples for physical testing per acre	1	1	1	1	1	1
Remediation area (acre)	0.0	0.0	0.0	0.0	0.0	0.0
Daily labor, equipment, materials (note 2)	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
No. of monitoring days (note 3)	-	-	-	-	-	-
Bathymetry (note 4)	$0	$0	$0	$0	$0	$0
Subtotal per event analytical cost (note 5)	$0	$0	$0	$0	$0	$0
Subtotal per event labor, equipment and materials cost	$0	$0	$0	$0	$0	$0
Data management, analysis and reporting (note 6)	$0	$0	$0	$0	$0	$0
Total monitoring costs per event	$0	$0	$0	$0	$0	$0
Total monitoring cost NPV assuming years 2, 5, 10	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
ENR						
Analytical cost per sample (note 1)	$675	$675	$675	$675	$675	$675
No. of surface sediment samples per acre	2	2	2	2	2	2
No. of porewater samples per acre	2	2	2	2	2	2
No. of cores per acre	0	0	0	0	0	0
No. of samples for physical testing per acre	2	2	2	2	2	2
Remediation area (acre)	12.6	1.6	0.6	0.7	0.0	0.0
Daily labor, equipment, materials (note 2)	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
No. of monitoring days (note 3)	2	0	0	0	-	-
Bathymetry (note 4)	$12,198	$3,536	$1,963	$2,153	$0	$0
Subtotal per event analytical cost (note 5)	$34,020	$4,320	$1,620	$1,890	$0	$0
Subtotal per event labor, equipment and materials cost	$26,898	$5,403	$2,663	$2,970	$0	$0
Data management, analysis and reporting (note 6)	$36,586	$10,606	$5,888	$6,459	$0	$0
Total monitoring costs per event	$97,503	$20,329	$10,171	$11,319	$0	$0
Total monitoring cost NPV assuming years 2, 5, 10	**$257,865**	**$53,764**	**$26,900**	**$29,934**	**$0**	**$0**
MNR						
Analytical cost per sample (note 1)	$675	$675	$675	$675	$675	$675
No. of surface sediment samples per acre	2	2	2	2	2	2
No. of porewater samples per acre	0	0	0	0	0	0
No. of cores per acre	0	0	0	0	0	0
No. of samples for physical testing per acre	2	2	2	2	2	2
Remediation area (acre)	139	14	0	2	7	74
Daily labor, equipment, materials (note 2)	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
No. of monitoring days (note 3)	23	2	-	0	1	12
Bathymetry (note 4)	$51,506	$13,105	$0	$3,402	$8,719	$35,142
Subtotal per event analytical cost (note 5)	$187,650	$19,170	$0	$2,025	$9,720	$99,225
Subtotal per event labor, equipment and materials cost	$213,673	$29,671	$0	$5,152	$17,119	$120,892
Data management, analysis and reporting (note 6)	$154,489	$39,306	$0	$10,203	$26,151	$105,405
Total monitoring costs per event	$555,812	$88,148	$0	$17,380	$52,990	$325,522
Years of monitoring (10, 20, or 30)	20	10	10	10	10	10
Total monitoring cost NPV assuming every 5 years	**$1,686,728**	**$148,893**	**$0**	**$29,357**	**$89,507**	**$549,850**
Repair Costs for ENR - 5% of area						
ENR						
Area (acre)	0.6	0.1	0.0	0.0	0.0	0.0
Cost per acre	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Total repair cost per event	$63,000	$8,000	$3,000	$3,500	$0	$0
Total repair cost NPV assuming years 5, 10	**$106,415**	**$13,513**	**$5,067**	**$5,912**	**$0**	**$0**
Contingency Remediation for MNR and ENR - 5% of area						
MNR and ENR						
Area (acre)	7.6	0.8	0.0	0.1	0.4	3.7
Cost per acre	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000
Total cost per event	$2,274,000	$237,000	$9,000	$33,000	$108,000	$1,102,500
Total contingency cost NPV assuming years 5, 10	**$3,841,091**	**$400,325**	**$15,202**	**$55,741**	**$182,426**	**$1,862,270**

1. Analytical costs for PCB, metals, pesticides, TOC and solids, although the list of analytes may be reduced for some DUs.
2. Daily labor, equipment, and materials rate is the assumed sampling labor and materials cost for all monitoring activities except survey.
3. Monitoring days equals the number of stations per acre times the number of acres divided by 15 stations per day.
4. Bathymetric costs calculated by scaling estimated cost of $100,000 for 420 acres (size of active DUs) using a power scaling function and power of 0.6:
i.e., cost(area A) = cost(site-wide) * (area A/420 acres)^0.6.
5. Analytical cost assumes 4 samples per core.
6. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $6,000 using a power scaling function and power of 0.6:
e.g., cost(area A) = (cost) * (area A)^0.6.

Table E-10: Remedial Goal Monitoring

No Active Remediation Areas (DUs N-1, W-1, M-1, and E-1)

Analyte	Number of Samples	Price per Sample ($)	Total Cost ($)
Surface Sediment (Note 1; includes PCBs, metals, pesticides, TOC and total solids)			
PCBs (congeners 8082)	110	$ 250	$ 27,500
Metals (antimony, cadmium, copper, lead, mercury, silver, zinc)	110	$ 140	$ 15,400
Pesticides (dieldrin, endosulfan)	110	$ 170	$ 18,700
TOC (9096)	110	$ 105	$ 11,550
Total solids	110	$ 10	$ 1,100
Subtotal surface sediment	110	$ 675	$ 74,250
Biota Tissue (Note 2)			
PCB congeners (EPA method 1668C) (whole body fish)	30	$ 850	$ 25,500
PCB congeners (EPA method 1668C) (fish fillets)	42	$ 850	$ 35,700
Total lipids	42	$ 60	$ 2,520
Total solids	42	$ 35	$ 1,470
Filleting/ Prep	42	$ 150	$ 6,300
Subtotal biota samples	42	$ 1,945	$ 71,490
		Total analytical cost	$ 145,740
Sample collection, data management, analysis, reporting, QC (assume 50% of analytical)			$ 72,870
Total cost per event			$ 218,610
Total cost NPV assuming monitoring in year 5 (note 3)			**$ 195,116**

Notes:

1. Number of samples estimated to calculate technically defensible SWACs = 100. With 10% duplicates, the total number of samples = 110. Analysis includes PCBs, metals, pesticides, TOC and total solids.

2. Bottomfish (i.e., bandtail goatfish [*Upeneus taeniopterus*]) tissue samples will be collected from 14 locations (approximately 42 samples) and analyzed to monitor PCB concentrations in biota within the NAR DUs. Each of the proposed fish tissue sampling locations is collocated with a proposed sediment sampling location. Collocated bandtail goatfish tissue/sediment samples were collected from 12 of these locations in 2009, and biota (tilapia, goatfish, and/or crab) tissue samples were collected at 6 of these locations in 1996. Analysis includes PCBs for whole fish and fillets, lipids, solids, and prep.

3. Sampling performed during first five-year review. Subsequent sampling events are contingent upon the results of the first round of sampling (see Appendix F for detailed monitoring criteria). For cost estimating, assume that no additional rounds of sampling are necessary (potential additional rounds of sampling are assumed to be part of contingency costs).

Table E-10: Remedial Goal Monitoring

DUs Potentially Requiring Active Remediation Areas (DUs SE-1, N-2, N-3, N-4, E-2, E-3)

Analyte	Number of Samples	Price per Sample ($)	Total Cost ($)
Surface Sediment (Note 1)			
Metals (antimony, cadmium, copper, lead, mercury, silver, zinc)	61	$ 220	$ 13,420
PCBs (as Congeners)	61	$ 220	$ 13,420
Pesticides (dieldrin, endosulfan)	61	$ 170	$ 10,370
TOC	61	$ 40	$ 2,440
Total solids	61	$ 10	$ 610
Subtotal surface sediment	61	$ 1,100	$ 67,100
		Total analytical cost	$ 67,100
Sample collection, data management, analysis, reporting, QC (50% of analytical)			$ 33,550
Total cost per event			$ 100,650
Total cost NPV assuming monitoring in years 15, 20, 25, 30			**$ 243,318**
Biota Tissue (Note 2)			
PCB congeners (EPA method 1668C) (whole body fish)	30	$ 850	$ 25,500
PCB congeners (EPA method 1668C) (fish fillets)	30	$ 850	$ 25,500
Total lipids	30	$ 60	$ 1,800
Total solids	30	$ 35	$ 1,050
Filleting/ Prep	30	$ 150	$ 4,500
Subtotal surface sediment	30	$ 1,945	$ 58,350
		Total analytical cost	$ 58,350
Sample collection, data management, analysis, reporting, QC (50% of analytical)			$ 29,175
Total cost per event			$ 87,525
Total cost NPV assuming monitoring in years 5, 10, 15, 20, 25, 30			**$ 359,430**

Notes:

1. Assume that the technology-specific operations and maintenance monitoring program provides sufficient monitoring through 10 years following construction. Six DUs potentially requiring active remediation comprise approximately 419 acres. Assumed monitoring frequency is 1 sample every 8 acres, or approximately 55 samples. With 10% duplicates, the total number of samples = 61. Assume all COCs will be analyzed for all DUs, although a subset may be analyzed in select DUs. Assume monitoring occurs until all COCs are below PRGs (or other regulatory criteria for fish tissue) for two consecutive 5-year reviews (due to persistence of chemicals in fish tissue assume 30 years post-construction for all alternatives).

2. Bottomfish (i.e., bandtail goatfish [*Upeneus taeniopterus*]) tissue samples will be collected from 10 locations (approximately 3 samples/each location) and analyzed to monitor PCB concentrations in biota within the further action DUs. Assume that monitoring will occur every 5 years for 30 years, until fish tissue concentrations are below regulatory criteria for two consecutive monitoring events.

3. Monitoring costs are assumed to include costs for reporting and agency review and oversight during five-year reviews.

Table E-11: Areas and Volumes

Item	Unit	SE-1 Alt 13: Focused Dredging with ENR, AC, and MNR (20 Years)	N-2 Alt 10: ENR with MNR (10 Years)	N-3 Alt 4: ENR	N-4 Alt 4: ENR	E-2 Alt 8: Focused Dredging with MNR (10 Years)	E-3 Alt 2: MNR (10 Years)
Remedial Technology Areas							
Total Area (Overwater + Under Pier)	acre	161.3	16.7	0.6	2.7	8.7	73.5
Full Dredging	acre	2.0	0.0	0.0	0.0	1.5	0.0
ENR with No Partial Dredging	acre	12.6	1.6	0.6	0.7	0.0	0.0
Total ENR Area	acre	12.6	1.6	0.6	0.7	0.0	0.0
AC Amendment	acre	11.1	0.0	0.0	0.0	0.0	0.0
Under-pier AC Amendment	acre	8.0	0.7	0.0	0.0	0.0	0.0
Total Active Remediation	acre	33.7	2.3	0.6	0.7	1.5	0.0
MNR	acre	139.0	14.2	0.0	1.5	7.2	73.5
Dredging							
Dredging Volume	cy	11,325	0	0	0	5,000	0
Capping Clearance	cy	0	0	0	0	0	0
ENR Clearance	cy	0	0	0	0	0	0
Total Removal (neat volume)	cy	11,325	0	0	0	5,000	0
Estimated total dredging volume (neat volume * constructability factor)	cy	16,988	0	0	0	7,500	0
Dredge Days (assuming 2 operations)	day	21	0	0	0	9	0
Material Placement							
Dredge Residuals Import Material (assume 9in placement to achieve 6in minimum)	cy	1,222	0	0	0	914	0
Cap/PDC import material (assume 3.5ft of material placement to achieve 3ft cap)	cy	0	0	0	0	0	0
ENR Import Material (assume 9in placement to achieve 6in minimum)	cy	15,246	1,936	726	847	0	0
Total Material Placement (not including under pier)	cy	16,468	1,936	726	847	914	0
Total Thin Placement Import Material	cy	16,468	1,936	726	847	914	0
Dredge Residuals days (assuming 1 operation)	day	2	0	0	0	1	0
Cap/ PDC days (assuming 1 operation)	day	0	0	0	0	0	0
ENR Days (assuming 1 operation)	day	18.8	2.4	0.9	1.0	0.0	0.0
AC Amendment Under Piers							
Limited access areas (e.g., under pier)	acre	8	1	0	0	0	0
Import material (assume 1.5ft of material placement to achieve 1ft minimum)	cy	19,267	1,686	0	0	0	0
Under-pier days (assuming 1 operation)	day	193	17	0	0	0	0
Total Import Placement Volume	cy	35,735	3,622	726	847	914	0
Construction Time Frame							
Total construction days for one operation	day	256	19	1	1	20	0
Total construction months assuming 3 open-water operations and 1 under-pier operation and 302 work days per year (6 days/week for 52 weeks minus 10 holidays) - 12 months/ year	month	7.7	0.7	0.0	0.0	0.3	0.0
Total construction years assuming 3 open-water operations and 302 work days per year (6 days/week for 52 weeks minus 10 holidays) and 1 under-pier operation	year	0.6	0.1	0.0	0.0	0.0	0.0

Table E-12: Cost Summary

			SE-1 Alt 13: Focused Dredging with ENR, AC, and MNR (20 Years)	N-2 Alt 10: ENR with MNR (10 Years)	N-3 Alt 4: ENR	N-4 Alt 4: ENR	E-2 Alt 8: Focused Dredging with MNR (10 Years)	E-3 Alt 2: MNR (10 Years)
			Quantity / Subtotal	Quantity / Subtotal	Quantity / Subtotal	Quantity / Subtotal	Quantity / Subtotal	Quantity / Subtotal
Preconstruction								
Mobilization, Demobilization and Site Restoration (project - included with DU SE-1 only)	$1,540,000	PROJECT	1	0	0	0	0	0
Land Lease for Operations and Staging for Project Duration (assume	$0	YEAR	0.6	0.1	0.0	0.0	0.0	-
Subtotal:			**$1,540,000**	**$0**	**$0**	**$0**	**$0**	**$0**
Project Management (Contractor)								
Labor and Supervision	$62,000	MONTH	8	1	0.01	0.01	0.27	-
Construction Office and Operating Expense	$21,600	MONTH	8	1	0.01	0.01	0.27	-
Subtotal:			**$640,011**	**$56,001**	**$993**	**$1,159**	**$22,212**	**$0**
Dredging								
Total Dredge Volume		CY	16,988	-	-	-	7,500	-
Labor and Equipment Cost per Dredge Day (assume 2 operations)	$28,000	DAY	21	0	0	0	9	0
Subtotal:			**$600,295**	**$0**	**$0**	**$0**	**$265,031**	**$0**
Sediment Handling And Disposal								
Gravity Dewatering (on the barge)	$10	CY	16,988	-	-	-	7,500	-
Water Management	$10,000	DAY	21	0	0	0	9	0
Disposal: Transload, Transportation, Tipping	$111	TON	25,481	-	-	-	11,250	-
Disposal of RCRA Material: Transload, Transportation, and Tipping on	$540	TON	100	-	-	-	-	-
Subtotal:			**$3,268,791.83**	**$0**	**$0**	**$0**	**$1,419,334**	**$0**
Dredge Residuals Placement								
Total Placement Volume, material procurement and delivery (sand)	$83	CY	1,222	0	0	0	914	0
Labor and Equipment Cost per Day (assume 1 operation)	$14,000	DAY	2	0	0	0	1	0
Subtotal:			**$121,967**	**$0**	**$0**	**$0**	**$91,173**	**$0**
Enhanced Natural Recovery								
Total Placement Volume, material procurement and delivery (sand)	$156	CY	15,246	1,936	726	847	0	0
Labor and Equipment Cost per Day (assume 1 operation)	$14,000	DAY	19	2	1	1	0	0
Subtotal:			**$2,639,861**	**$335,220**	**$125,708**	**$146,659**	**$0**	**$0**
Underpier In-Situ AC Amendment Treatment								
Area	$500,000	ACRE	8	1	0	0	0	0
Subtotal:			**$4,000,000**	**$350,000**	**$0**	**$0**	**$0**	**$0**
Construction QA/QC								
Construction Monitoring	$3,486	DAY	50	-	-	-	11	-
Subtotal:			**$173,544**	**$0**	**$0**	**$0**	**$36,927**	**$0**
Post-Construction Performance Monitoring								
Compliance Testing (Dredging)	alt specific	PROJECT	$21,349	$0	$0	$0	$17,460	$0
Compliance Testing (ENR)	alt specific	PROJECT	$80,493	$18,169	$9,361	$10,374	$0	$0
Subtotal:			**$101,842**	**$18,169**	**$9,361**	**$10,374**	**$17,460**	**$0**
AC Amendment -Overwater Areas								
Area	$142,000	ACRE	11	-	-	-	-	-
Subtotal:			**$1,576,200**	**$0**	**$0**	**$0**	**$0**	**$0**
Capital Cost (Base)			**$14,662,511**	**$759,390**	**$136,062**	**$158,192**	**$1,852,137**	**$0**
Capital Cost (Present Value)			**$14,662,511**	**$759,390**	**$136,062**	**$158,192**	**$1,852,137**	**$0**
Project Management	6%		$879,750.68	$45,563	$8,164	$9,492	$111,128	$0
Remedial Design	12%		$1,759,501	$91,127	$16,327	$18,983	$222,256	$0
Construction Management	8%		$1,173,001	$60,751	$10,885	$12,655	$148,171	$0
Scope Contingency	20%		$2,932,502	$151,878	$27,212	$31,638	$370,427	$0
Bid Contingency	15%		$2,199,377	$113,909	$20,409	$23,729	$277,820	$0
Sales Tax	4.0%		$586,500	$30,376	$5,442	$6,328	$74,085	$0
Total Capital Cost (Including Sum of Above)			**$24,193,144**	**$1,252,994**	**$224,503**	**$261,016**	**$3,056,025**	**$0**
Performance Monitoring and Remedial Goal Monitoring (present value)								
Performance Monitoring (Dredging)	alt specific	PROJECT	$34,757	$0	$0	$0	$28,755	$0
Performance Monitoring and Maintenance (ENR)	alt specific	PROJECT	$364,280	$67,277	$31,967	$35,846	$0	$0
Performance Monitoring (MNR)	alt specific	PROJECT	$1,686,728	$148,893	$0	$29,357	$89,507	$549,850
Contingency Remediation (MNR and ENR)	alt specific	PROJECT	$3,841,091	$400,325	$15,202	$55,741	$182,426	$1,862,270
Remedial Goal Monitoring (project - included with DU SE-1 only)	$797,864	PROJECT	$797,864	$0	$0	$0	$0	$0
Institutional Controls (project - included with DU SE-1 only)	$439,880	PROJECT	$439,880	$0	$0	$0	$0	$0
Subtotal:			**$7,164,600**	**$616,495**	**$47,169**	**$120,945**	**$300,688**	**$2,412,121**
Total Cost			**$31,357,744**	**$1,869,489**	**$271,672**	**$381,961**	**$3,356,714**	**$2,412,121**

Table E-13: Cost Sensitivity

	SE-1 Alt 13: Focused Dredging with ENR, AC, and MNR (20 Years)	N-2 Alt 10: ENR with MNR (10 Years)	N-3 Alt 4: ENR	N-4 Alt 4: ENR	E-2 Alt 8: Focused Dredging with MNR (10 Years)	E-3 Alt 2: MNR (10 Years)
Best Estimate Disposal: mixed CAD/CDF and upland disposal; Source material: mixed dredge reuse and upland source	$31,000,000	$1,900,000	$270,000	$380,000	$3,400,000	$2,400,000
Low Estimate Disposal: CAD/CDF; Source material: dredge reuse	$0	$0	$0	$0	$0	$0
High Estimate Disposal: upland disposal; Source material: upland	$0	$0	$0	$0	$0	$0

Attachment F:
Remedy Implementation Area Refinement
Based on 2017 Basis of Design Field Investigation

CONTENTS

FIGURE

TABLES

ACRONYMS AND ABBREVIATIONS

y^3	cubic yard
µg/kg	microgram per kilogram
AC	activated carbon
BOD	basis of design
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
DOH	Department of Health, State of Hawaii
DU	decision unit
ENR	enhanced natural recovery
EPA	Environmental Protection Agency, United States
FS	feasibility study
MNR	monitored natural recovery
PCB	polychlorinated biphenyl
PP	Proposed Plan
RAL	remedial action level
RI	remedial investigation
ROD	record of decision
SWAC	surface area–weighted average concentration

F. Refined Remedy Implementation Area Based on the 2017 Basis of Design Field Investigation

F.1 INTRODUCTION

This attachment presents the data and information which were used to refine the remedy implementation area and cost estimate for the selected remedial alternatives documented in this Record of Decision (ROD). The Navy conducted an additional field investigation from February through July of 2017 as part of the preparation of the Basis of Design (BOD) document for the design of the preferred remedial alternatives presented in the Feasibility Study (FS) and Proposed Plan, and documented as the selected remedial alternatives in this ROD. The BOD field investigation included additional surface and subsurface sediment sampling designed to supplement pre-existing data to refine the remedy implementation area in the remedial design stage.

Following consultation with the Environmental Protection Agency Region IX (EPA) and the State of Hawaii Department of Health (DOH), the Navy agreed to present the refined remedy implementation area in this ROD to provide the most recent and accurate estimate to implement the selected remedial alternatives. Therefore, this ROD includes updated information on the extent and cost of remediation for the selected remedial alternatives based on the additional data collected during the 2017 BOD field investigation for Decision Units (DUs) SE-1, N-2, N-4, and E2. DUs N-3 and E-3 did not require additional data and information to refine extent and cost of the selected remedial alternatives.

This attachment presents only the data and information related to the refined remedy implementation area and revised cost estimate for the preferred remedial alternatives. The complete results of the BOD investigation will be presented in the BOD document (in preparation) for the remedial design package.

F.2 REFINED REMEDY IMPLEMENTATION AREA AND COST ESTIMATE

Figure F-1 presents the FS *remediation footprint* for the preferred remedial alternatives for the six DUs identified for remediation in Pearl Harbor. *Remediation footprint* refers to the initial polygons or sub-areas developed in the FS based on combined 2009 RI Addendum and 2012 FS data to define the DU boundaries, calculate surface area-weighted average concentration (SWAC), and develop remedial action levels (RALs). The cost estimate developed and presented in the FS and the Proposed Plan was based on the assumption that the remedy will be implemented over the entire individual polygon or sub-area designated for a particular remedy. Figure F-2 through Figure F-6 presents the additional data from the 2017 BOD field investigation along with data from 2009 RI Addendum and 2012. This combined dataset was used to refine the actual area within each of the sub-area where the remedy should be implemented.

Based on the results of the additional 2017 BOD data, the actual *remedy implementation area* (Figure F-7 through Figure F-11) represents a small fraction of the FS *remediation footprint* (Figure F-1). Table F-1 summarizes the changes in the remedy implementation cost parameters based on the refined *remedy implementation areas* (Figure F-12). Portions of the *remediation footprint* that no longer require remediation based on the 2017 BOD data are designated as *remnant areas*. Following discussions with EPA and DOH, the Navy agreed to carry forward the *remnant areas* to be designated for MNR implementation, as a conservative measure.

Changes to the cost estimate based on the refined *remedy implementation area* and parameters are presented in the ROD only for the selected remedial alternatives (Attachment E). The BOD data was not used to re-calculate SWACs or RALs. Post-remedy SWAC calculations to measure the success of remedy implementation (i.e., meeting remedial action objectives) will continue to be based on the FS *remediation footprint*.

Table F-1: Remedy Implementation Parameters From the FS (DON 2015) Estimate Compared to the Refined Estimate Based on Additional 2017 Basis of Design Field Investigation Data

Selected Remedial Alternative Component	DU SE-1: Focused Dredging with ENR, AC, and MNR (20 Years)		DU N-2: ENR (10 Years)		DU N-4: ENR		DU E-2: Focused Dredging with MNR (10 Years)	
	FS/PP	ROD	FS/PP	ROD	FS/PP	ROD	FS/PP	ROD
Dredging (acre)	5.1	2.0	–	–	–	–	4.8	1.5
Dredging (y^3)	24,000	12,000	–	–	–	–	7,800	4,800
ENR + AC (acre)	12.1	3.1	–	–	–	–	–	–
MNR + AC (acre)	23.7	8.1	–	–	–	–	–	–
ENR (acre)	20.5	9.5	3.2	1.6	2.3	0.7	–	–
MNR (acre)	89.1	89.1	12.6	12.6	–	–	3.9	3.9
Remnant Area for MNR (acre)	–	38.7	–	1.6	–	1.6	–	3.7

– not applicable
AC activated carbon amendment treatment
DU Decision Unit
ENR enhanced natural recovery
FS feasibility study
MNR monitored natural recovery
PP Proposed Plan
ROD record of decision
y^3 cubic yard

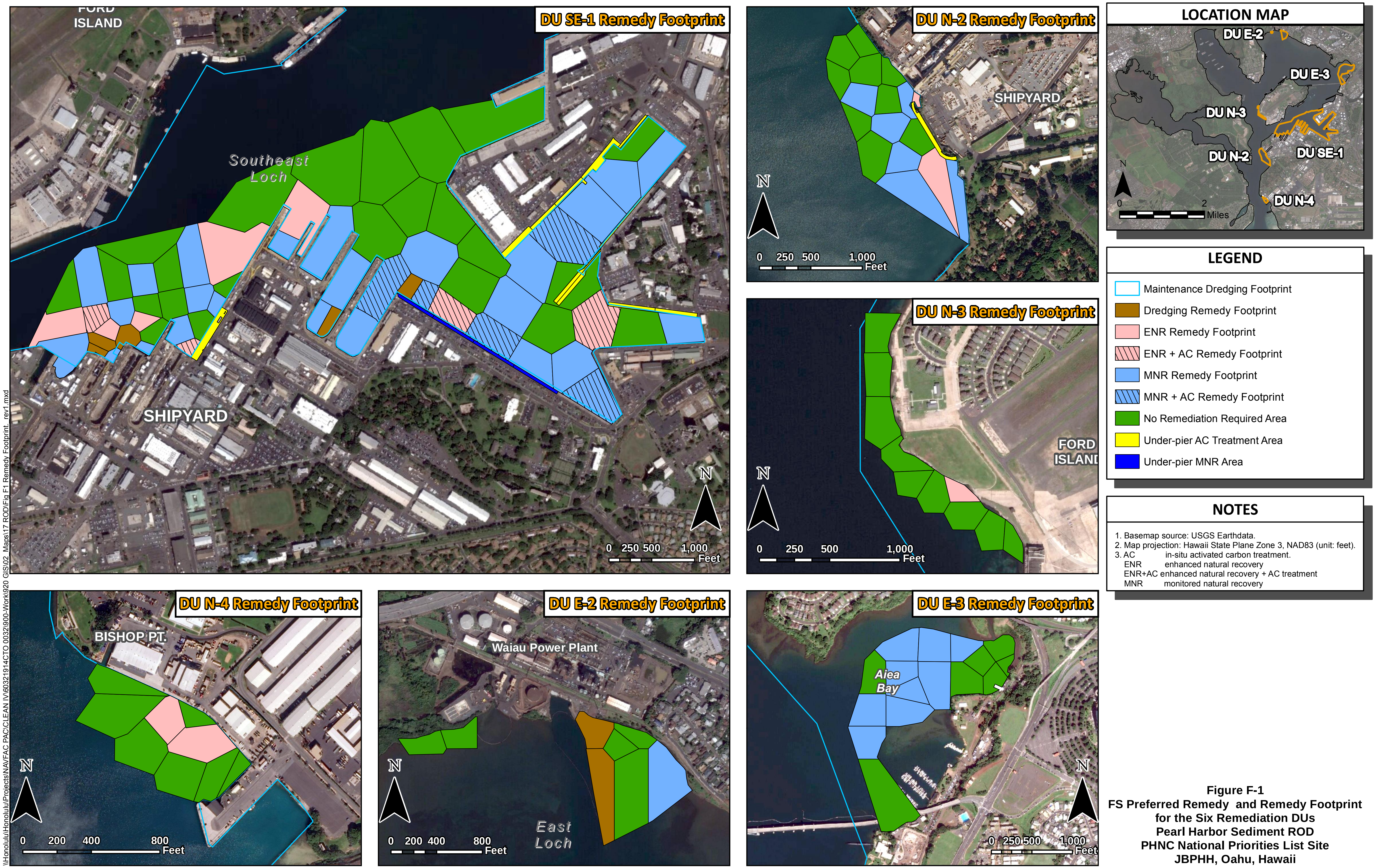
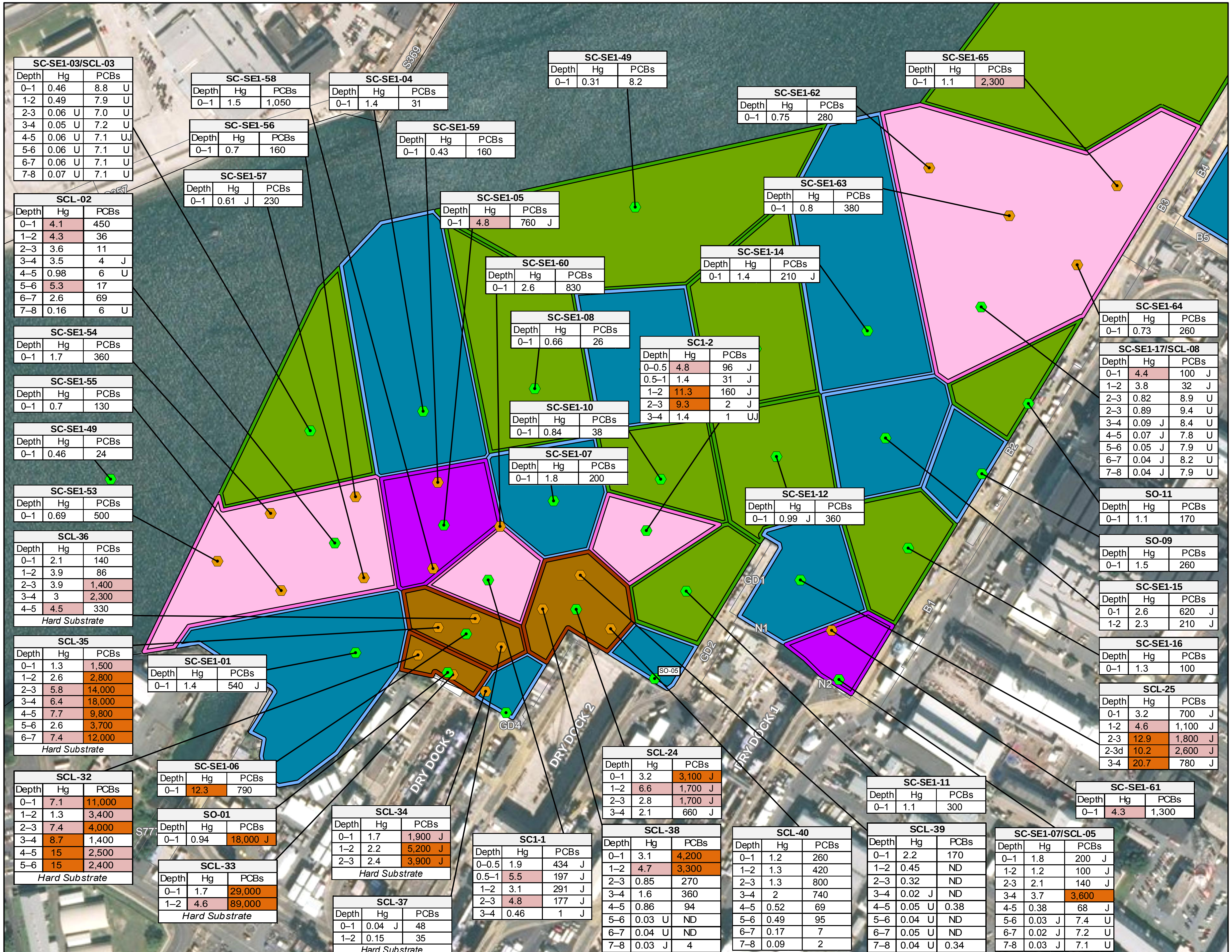


Figure F-1
FS Preferred Remedy and Remedy Footprint for the Six Remediation DUs
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii



SC-SE1-03/SCL-03

Depth	Hg	PCBs
0–1	0.46	8.8 U
1–2	0.49	7.9 U
2–3	0.06 U	7.0 U
3–4	0.05 U	7.2 U
4–5	0.06 U	7.1 UJ
5–6	0.06 U	7.1 U
6–7	0.06 U	7.1 U
7–8	0.07 U	7.1 U

SC-SE1-58

Depth	Hg	PCBs
0–1	1.5	1,050

SC-SE1-04

Depth	Hg	PCBs
0–1	1.4	31

SC-SE1-56

Depth	Hg	PCBs
0–1	0.7	160

SC-SE1-59

Depth	Hg	PCBs
0–1	0.43	160

SC-SE1-57

Depth	Hg	PCBs
0–1	0.61 J	230

SC-SE1-49

Depth	Hg	PCBs
0–1	0.31	8.2

SC-SE1-05

Depth	Hg	PCBs
0–1	4.8	760 J

SC-SE1-65

Depth	Hg	PCBs
0–1	1.1	2,300

SC-SE1-62

Depth	Hg	PCBs
0–1	0.75	280

SC-SE1-63

Depth	Hg	PCBs
0–1	0.8	380

SC-SE1-14

Depth	Hg	PCBs
0-1	1.4	210 J

SC-SE1-60

Depth	Hg	PCBs
0–1	2.6	830

SC-SE1-08

Depth	Hg	PCBs
0–1	0.66	26

SC1-2

Depth	Hg	PCBs
0–0.5	4.8	96 J
0.5–1	1.4	31 J
1–2	11.3	160 J
2–3	9.3	2 J
3–4	1.4	1 UJ

SC-SE1-10

Depth	Hg	PCBs
0–1	0.84	38

SC-SE1-07

Depth	Hg	PCBs
0–1	1.8	200

SC-SE1-12

Depth	Hg	PCBs
0–1	0.99 J	360

SCL-02

Depth	Hg	PCBs
0–1	4.1	450
1–2	4.3	36
2–3	3.6	11
3–4	3.5	4 J
4–5	0.98	6 U
5–6	5.3	17
6–7	2.6	69
7–8	0.16	6 U

SC-SE1-54

Depth	Hg	PCBs
0–1	1.7	360

SC-SE1-55

Depth	Hg	PCBs
0–1	0.7	130

SC-SE1-49

Depth	Hg	PCBs
0–1	0.46	24

SC-SE1-53

Depth	Hg	PCBs
0–1	0.69	500

SCL-36

Depth	Hg	PCBs
0–1	2.1	140
1–2	3.9	86
2–3	3.9	1,400
3–4	3	2,300
4–5	4.5	330
Hard Substrate		

SCL-35

Depth	Hg	PCBs
0–1	1.3	1,500
1–2	2.6	2,800
2–3	5.8	14,000
3–4	6.4	18,000
4–5	7.7	9,800
5–6	2.6	3,700
6–7	7.4	12,000
Hard Substrate		

SC-SE1-01

Depth	Hg	PCBs
0–1	1.4	540 J

SCL-32

Depth	Hg	PCBs
0–1	7.1	11,000
1–2	1.3	3,400
2–3	7.4	4,000
3–4	8.7	1,400
4–5	15	2,500
5–6	15	2,400
Hard Substrate		

SC-SE1-06

Depth	Hg	PCBs
0–1	12.3	790

SO-01

Depth	Hg	PCBs
0–1	0.94	18,000 J

SCL-33

Depth	Hg	PCBs
0–1	1.7	29,000
1–2	4.6	89,000
Hard Substrate		

SCL-34

Depth	Hg	PCBs
0–1	1.7	1,900 J
1–2	2.2	5,200 J
2–3	2.4	3,900 J
Hard Substrate		

SCL-37

Depth	Hg	PCBs
0–1	0.04 J	48
1–2	0.15	35
Hard Substrate		

SC1-1

Depth	Hg	PCBs
0–0.5	1.9	434 J
0.5–1	5.5	197 J
1–2	3.1	291 J
2–3	4.8	177 J
3–4	0.46	1 J

SCL-24

Depth	Hg	PCBs
0–1	3.2	3,100 J
1–2	6.6	1,700 J
2–3	2.8	1,700 J
3–4	2.1	660 J

SCL-38

Depth	Hg	PCBs
0–1	3.1	4,200
1–2	4.7	3,300
2–3	0.85	270
3–4	1.6	360
4–5	0.86	94
5–6	0.03 U	ND
6–7	0.04 U	ND
7–8	0.03 J	4

SCL-40

Depth	Hg	PCBs
0–1	1.2	260
1–2	1.3	420
2–3	1.3	800
3–4	2	740
4–5	0.52	69
5–6	0.49	95
6–7	0.17	7
7–8	0.09	2

SC-SE1-11

Depth	Hg	PCBs
0–1	1.1	300

SCL-39

Depth	Hg	PCBs
0–1	2.2	170
1–2	0.45	ND
2–3	0.32	ND
3–4	0.02 J	ND
4–5	0.05 U	0.38
5–6	0.04 U	ND
6–7	0.05 U	ND
7–8	0.04 U	0.34

SC-SE1-07/SCL-05

Depth	Hg	PCBs
0–1	1.8	200 J
1-2	1.2	100 J
2-3	2.1	140 J
3-4	3.7	3,600
4-5	0.38	68 J
5-6	0.03 J	7.4 U
6-7	0.02 J	7.2 U
7-8	0.03 J	7.1 U

SC-SE1-61

Depth	Hg	PCBs
0–1	4.3	1,300

SC-SE1-64

Depth	Hg	PCBs
0–1	0.73	260

SC-SE1-17/SCL-08

Depth	Hg	PCBs
0–1	4.4	100 J
1–2	3.8	32 J
2–3	0.82	8.9 U
2–3	0.89	9.4 U
3–4	0.09 J	8.4 U
4–5	0.07 J	7.8 U
5–6	0.05 J	7.9 U
6–7	0.04 J	8.2 U
7–8	0.04 J	7.9 U

SO-11

Depth	Hg	PCBs
0–1	1.1	170

SO-09

Depth	Hg	PCBs
0–1	1.5	260

SC-SE1-15

Depth	Hg	PCBs
0-1	2.6	620 J
1-2	2.3	210 J

SC-SE1-16

Depth	Hg	PCBs
0–1	1.3	100

SCL-25

Depth	Hg	PCBs
0-1	3.2	700 J
1–2	4.6	1,100 J
2-3	12.9	1,800 J
2-3d	10.2	2,600 J
3-4	20.7	780 J

LEGEND

- 2009 and 2012 Sediment Sampling Location
- 2017 Sediment Sampling Location

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for Dredging
- Sub-Area Designated for ENR
- Sub-Area Designated for ENR + AC
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy
- Concentration > Dredging Action Level (PCBs > 2,600 µg/kg; Hg > 8 mg/kg)
- Concentration > ENR Action Level (PCBs > 1,300 µg/kg; Hg > 4 mg/kg)

NOTES

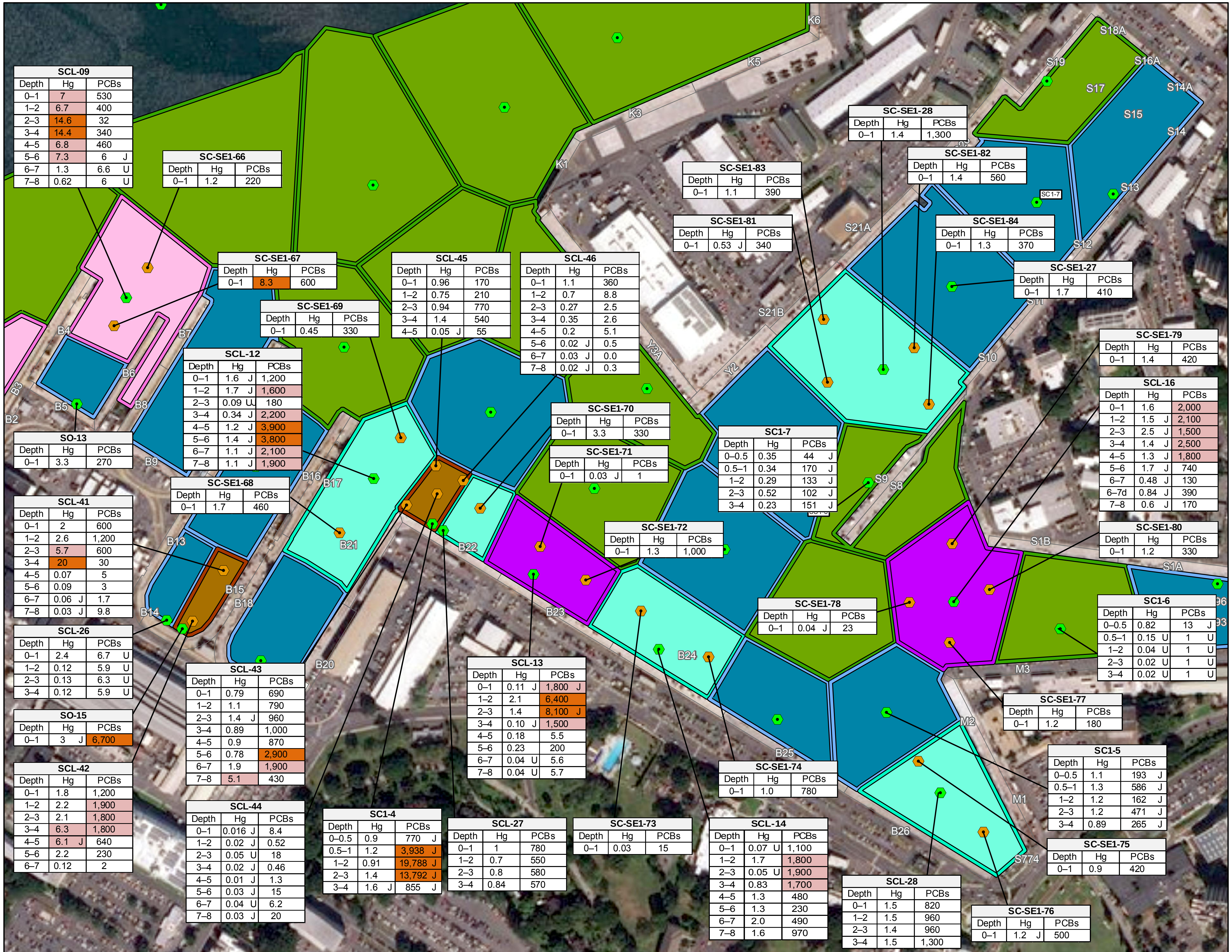
1. Map Projection: UTM State Plane Zone 3 unit feet, NAD 83 Datum.
2. Sediment data are from the 2009 RI Addendum, 2012 FS, and 2017 BOD Field Investigation.
3. Activated carbon (AC) amendment included with ENR or MNR is designated for areas where PCBs > 740 µg/kg

N

0 125 250 500 Feet

Figure F-2
Summary of 2009, 2012 and 2017 Sediment PCBs and Mercury Concentration for DU SE-1 (Southeast Loch) Dry Docks 1, 2, and 3 Remediation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

S:\Projects\NAVFAC PAC\CLEAN IV\60321914\CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig F2 - DU SE1 Dry Dock Sediment Results.mxd



SCL-09

Depth	Hg	PCBs
0–1	7	530
1–2	6.7	400
2–3	14.6	32
3–4	14.4	340
4–5	6.8	460
5–6	7.3	6 J
6–7	1.3	6.6 U
7–8	0.62	6 U

SC-SE1-66

Depth	Hg	PCBs
0–1	1.2	220

SC-SE1-67

Depth	Hg	PCBs
0–1	8.3	600

SC-SE1-69

Depth	Hg	PCBs
0–1	0.45	330

SCL-45

Depth	Hg	PCBs
0–1	0.96	170
1–2	0.75	210
2–3	0.94	770
3–4	1.4	540
4–5	0.05 J	55

SCL-46

Depth	Hg	PCBs
0–1	1.1	360
1–2	0.7	8.8
2–3	0.27	2.5
3–4	0.35	2.6
4–5	0.2	5.1
5–6	0.02 J	0.5
6–7	0.03 J	0.0
7–8	0.02 J	0.3

SC-SE1-83

Depth	Hg	PCBs
0–1	1.1	390

SC-SE1-81

Depth	Hg	PCBs
0–1	0.53 J	340

SC-SE1-28

Depth	Hg	PCBs
0–1	1.4	1,300

SC-SE1-82

Depth	Hg	PCBs
0–1	1.4	560

SC-SE1-84

Depth	Hg	PCBs
0–1	1.3	370

SC-SE1-27

Depth	Hg	PCBs
0–1	1.7	410

SC-SE1-79

Depth	Hg	PCBs
0–1	1.4	420

SCL-16

Depth	Hg	PCBs
0–1	1.6	2,000
1–2	1.5 J	2,100
2–3	2.5 J	1,500
3–4	1.4 J	2,500
4–5	1.3 J	1,800
5–6	1.7 J	740
6–7	0.48 J	130
6–7d	0.84 J	390
7–8	0.6 J	170

SCL-12

Depth	Hg	PCBs
0–1	1.6 J	1,200
1–2	1.7 J	1,600
2–3	0.09 UJ	180
3–4	0.34 J	2,200
4–5	1.2 J	3,900
5–6	1.4 J	3,800
6–7	1.1 J	2,100
7–8	1.1 J	1,900

SO-13

Depth	Hg	PCBs
0–1	3.3	270

SC-SE1-70

Depth	Hg	PCBs
0–1	3.3	330

SC-SE1-71

Depth	Hg	PCBs
0–1	0.03 J	1

SC1-7

Depth	Hg	PCBs
0–0.5	0.35	44 J
0.5–1	0.34	170 J
1–2	0.29	133 J
2–3	0.52	102 J
3–4	0.23	151 J

SC-SE1-68

Depth	Hg	PCBs
0–1	1.7	460

SCL-41

Depth	Hg	PCBs
0–1	2	600
1–2	2.6	1,200
2–3	5.7	600
3–4	20	30
4–5	0.07	5
5–6	0.09	3
6–7	0.06 J	1.7
7–8	0.03 J	9.8

SC-SE1-72

Depth	Hg	PCBs
0–1	1.3	1,000

SC-SE1-80

Depth	Hg	PCBs
0–1	1.2	330

SC1-6

Depth	Hg	PCBs
0–0.5	0.82	13 J
0.5–1	0.15 U	1 U
1–2	0.04 U	1 U
2–3	0.02 U	1 U
3–4	0.02 U	1 U

SC-SE1-78

Depth	Hg	PCBs
0–1	0.04 J	23

SCL-26

Depth	Hg	PCBs
0–1	2.4	6.7 U
1–2	0.12	5.9 U
2–3	0.13	6.3 U
3–4	0.12	5.9 U

SCL-43

Depth	Hg	PCBs
0–1	0.79	690
1–2	1.1	790
2–3	1.4 J	960
3–4	0.89	1,000
4–5	0.9	870
5–6	0.78	2,900
6–7	1.9	1,900
7–8	5.1	430

SCL-13

Depth	Hg	PCBs
0–1	0.11 J	1,800 J
1–2	2.1	6,400
2–3	1.4	8,100 J
3–4	0.10 J	1,500
4–5	0.18	5.5
5–6	0.23	200
6–7	0.04 U	5.6
7–8	0.04 U	5.7

SC-SE1-77

Depth	Hg	PCBs
0–1	1.2	180

SO-15

Depth	Hg	PCBs
0–1	3 J	6,700

SC1-5

Depth	Hg	PCBs
0–0.5	1.1	193 J
0.5–1	1.3	586 J
1–2	1.2	162 J
2–3	1.2	471 J
3–4	0.89	265 J

SC-SE1-74

Depth	Hg	PCBs
0–1	1.0	780

SCL-42

Depth	Hg	PCBs
0–1	1.8	1,200
1–2	2.2	1,900
2–3	2.1	1,800
3–4	6.3	1,800
4–5	6.1 J	640
5–6	2.2	230
6–7	0.12	2

SCL-44

Depth	Hg	PCBs
0–1	0.016 J	8.4
1–2	0.02 J	0.52
2–3	0.05 U	18
3–4	0.02 J	0.46
4–5	0.01 J	1.3
5–6	0.03 J	15
6–7	0.04 U	6.2
7–8	0.03 J	20

SC1-4

Depth	Hg	PCBs
0–0.5	0.9	770 J
0.5–1	1.2	3,938 J
1–2	0.91	19,788 J
2–3	1.4	13,792 J
3–4	1.6 J	855 J

SCL-27

Depth	Hg	PCBs
0–1	1	780
1–2	0.7	550
2–3	0.8	580
3–4	0.84	570

SC-SE1-73

Depth	Hg	PCBs
0–1	0.03	15

SCL-14

Depth	Hg	PCBs
0–1	0.07 U	1,100
1–2	1.7	1,800
2–3	0.05 U	1,900
3–4	0.83	1,700
4–5	1.3	480
5–6	1.3	230
6–7	2.0	490
7–8	1.6	970

SC-SE1-75

Depth	Hg	PCBs
0–1	0.9	420

SCL-28

Depth	Hg	PCBs
0–1	1.5	820
1–2	1.5	960
2–3	1.4	960
3–4	1.5	1,300

SC-SE1-76

Depth	Hg	PCBs
0–1	1.2 J	500

LEGEND

- 2009 and 2012 Sediment Sampling Location
- 2017 Sediment Sampling Location

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for Dredging
- Sub-Area Designated for ENR
- Sub-Area Designated for ENR + AC
- Sub-Area Designated for MNR
- Sub-Area Designated for MNR + AC
- Sub-Area Designated for No Remedy
- Concentration > Dredging Action Level (PCBs > 2,600 μg/kg; Hg > 8 mg/kg)
- Concentration > ENR Action Level (PCBs > 1,300 μg/kg; Hg > 4 mg/kg)

NOTES

1. Map Projection: UTM State Plane Zone 3 unit feet, NAD 83 Datum.
2. Sediment data are from the 2009 RI Addendum, 2012 FS, and 2017 BOD Field Investigation.
3. Activated carbon (AC) amendment included with ENR or MNR is designated for areas where PCBs > 740 μg/kg

N

0 250 500 1,000 Feet

Figure F-3
DU SE-1 Southeast Loch Basin Remediation Area Combined 2009, 2012, and 2017 PCBs and Mercury Concentration Distribution
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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LEGEND

- 2009 and 2012 Sediment Sampling Location
- 2017 Sediment Sampling Location

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for ENR
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy
- 780 Concentration > ENR Action Level (PCBs > 670 µg/kg; Hg > 2.3 mg/kg)
- 500 Concentration > ENR Action Level (PCBs > 380 µg/kg; Hg > 1.4 mg/kg)

NOTES

1. Map Projection: UTM State Plane Zone 3 unit feet, NAD 83 Datum.
2. Sediment data are from the 2009 RI Addendum, 2012 FS, and 2017 BOD Field Investigation.

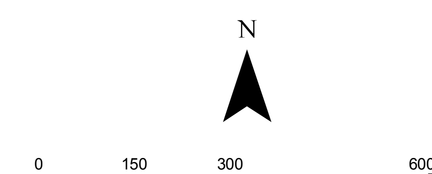

Figure F-4
DU N-2 Oscar 1 and 2 Piers Shoreline
Combined 2009, 2012, and 2017 Sediment
PCBs and Mercury Concentration Distribution
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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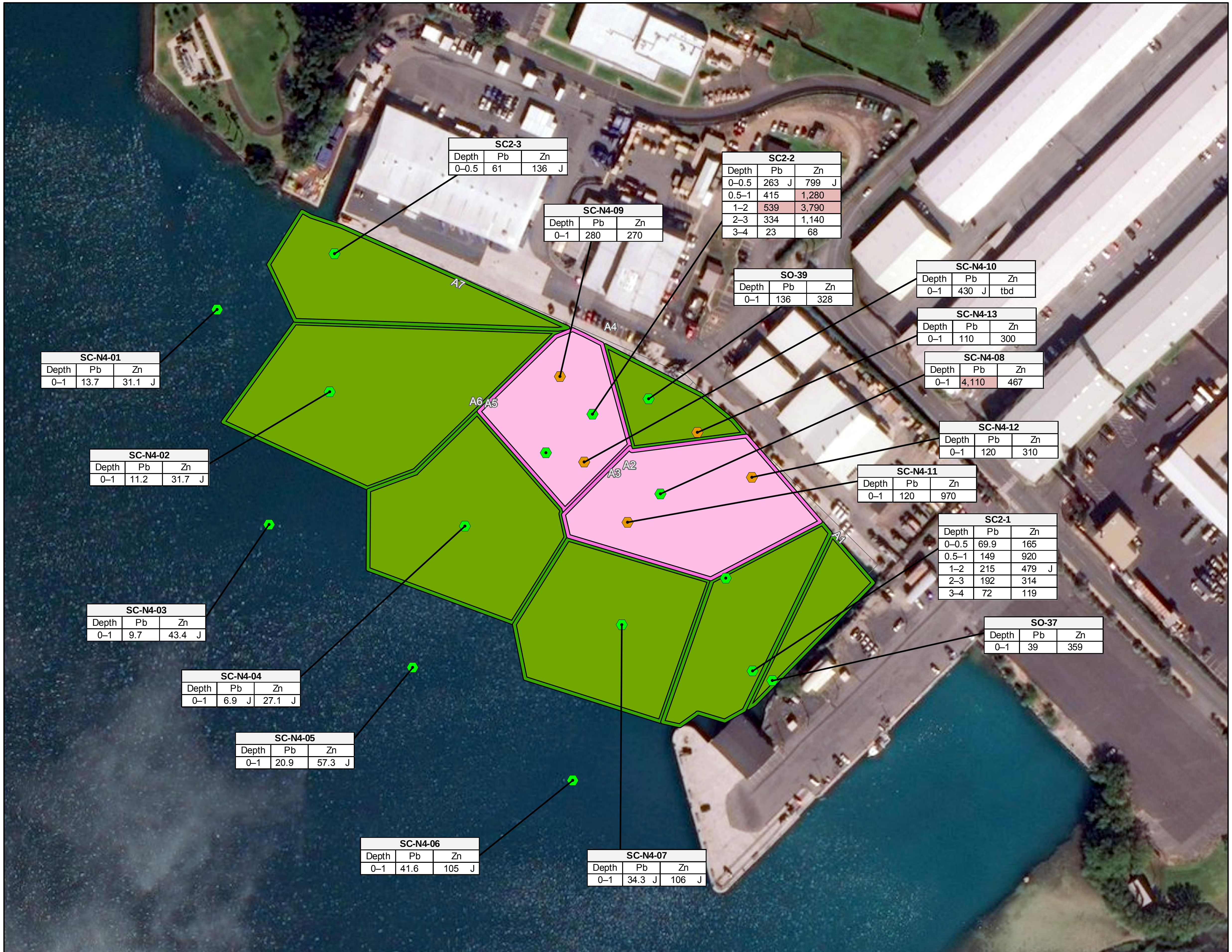


LEGEND

- 2009 and 2012 Sediment Sampling Location
- 2017 Sediment Sampling Location

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for ENR
- Sub-Area Designated for No Remedy
- Concentration > ENR Action Level (Pb >420 mg/kg; Zn > 1,200 mg/kg)

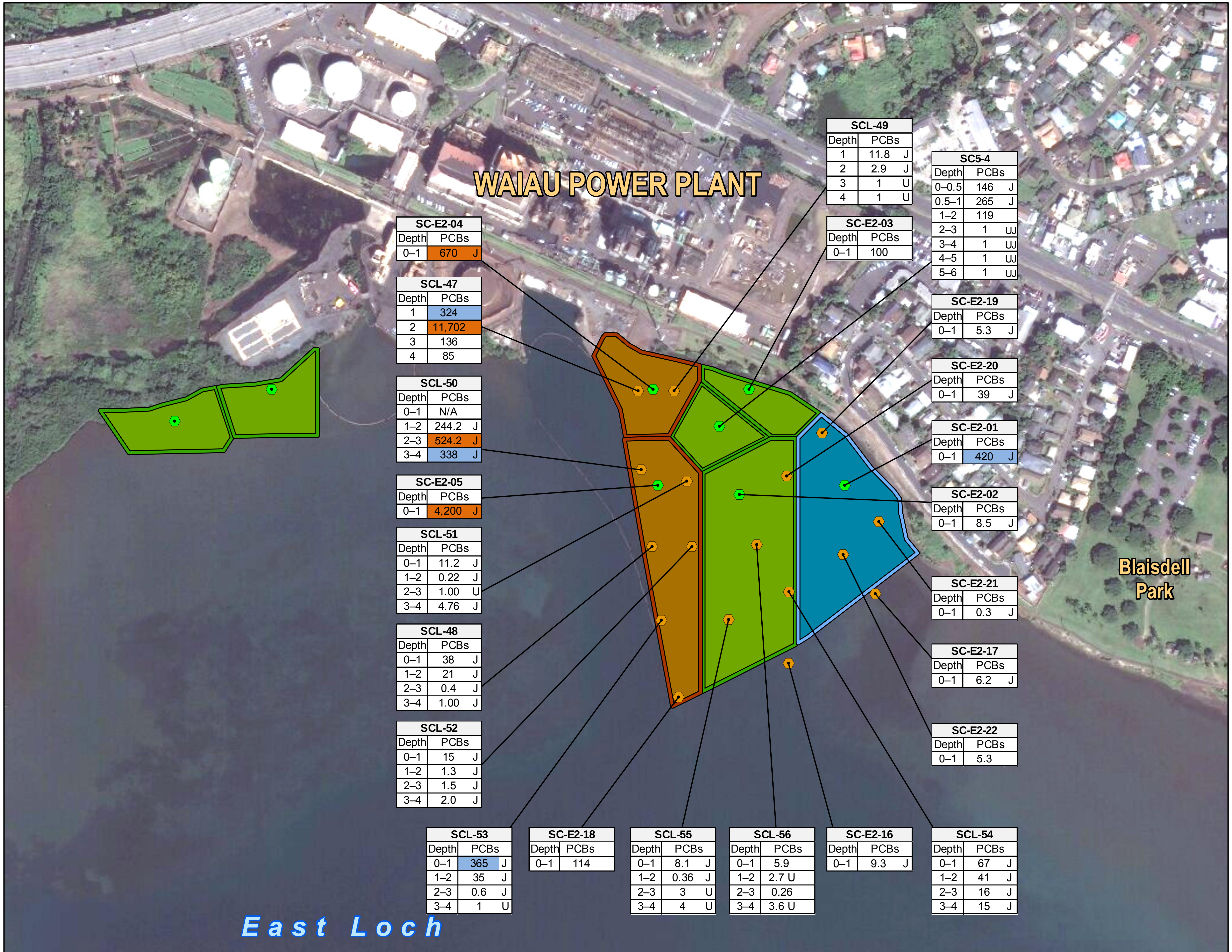
NOTES

1. Map Projection: UTM State Plane Zone 3 unit feet, NAD 83 Datum.
2. Sediment data are from the 2009 RI Addendum, 2012 FS, and 2017 BOD Field Investigation.

N

0 75 150 300 Feet

Figure F-5
DU N-4 Bishop Point Combined 2009, 2012, and 2017 Sediment Lead and Zinc Concentration Distribution
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii



LEGEND

- 2009 and 2012 Sediment Sampling Location
- 2017 Sediment Sampling Location

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for Dredging
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy
- Concentration > Dredging Action Level (PCBs > 470 µg/kg)
- Concentration > MNR Action Level (PCBs > 270 µg/kg)

NOTES

1. Map Projection: UTM State Plane Zone 3 unit feet, NAD 83 Datum.
2. Sediment data are from the 2009 RI Addendum, 2012 FS, and 2017 BOD Field Investigation.
3. Depth column in data boxes is in feet below mean lower low water (ft. MLLW); PCBs concentration in unit µg/kg.

N

0 150 300 600 Feet

Figure F-6
DU E-2 Off Waiau Power Plant
Combined 2009, 2012, and 2017 Sediment PCBs Concentration Distribution
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

LEGEND

- 2009 and 2012 Sediment Sampling Location
- 2017 Sediment Sampling Location

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for Dredging
- Sub-Area Designated for ENR
- Sub-Area Designated for ENR + AC
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy

Refined Remedy Implementation Area

- Dredging Implementation Area
- ENR Implementation Area
- ENR + AC Implementation Area
- MNR Implementation Area
- Remnant Area Designated for MNR

NOTES

1. Map Projection: UTM State Plane Zone 3 unit feet, NAD 83 Datum.

N

0 125 250 500 Feet

Figure F7
DU SE-1 Dry Docks 1,2, and 3
Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

Document Path: \\Honolulu\Honolulu\Projects\NAVFAC PAC\CLEAN IV\60321914CTO 0032\900-Work\920 GIS\02_Maps\17 ROD\Fig F8 - SE Loch Basin Rem Impl Area.mxd

LEGEND

- 2009 and 2012 Sediment Sampling Location
- 2017 Sediment Sampling Location

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for Dredging
- Sub-Area Designated for ENR
- Sub-Area Designated for ENR + AC
- Sub-Area Designated for MNR
- Sub-Area Designated for MNR + AC
- Sub-Area Designated for No Remedy

Refined Remedy Implementation Area

- Dredging Implementation Area
- ENR Implementation Area
- ENR + AC Implementation
- MNR + AC Implementation
- MNR Implementation Area
- Remnant Area Designated for MNR

NOTES

1. Map Projection: UTM State Plane Zone 3 unit feet, NAD 83 Datum.

N

0 250 500 1,000 Feet

Figure F-8
DU SE-1 Southeast Loch Basin
Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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LEGEND

- 2009 and 2012 Sediment Sampling Location
- 2017 Sediment Sampling Location

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for ENR
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy

Refined Remedy Implementation Area

- Dredging Implementation
- ENR Implementation
- ENR + AC Implementation
- MNR + AC Implementation
- MNR Implementation
- Remnant Area Designated for

NOTES

1. Map Projection: UTM State Plane Zone 3 unit feet, NAD 83 Datum.

N

0 150 300 600 Feet

Figure F-9
DU N-2 (Oscar 1 and 2 Piers Shoreline)
Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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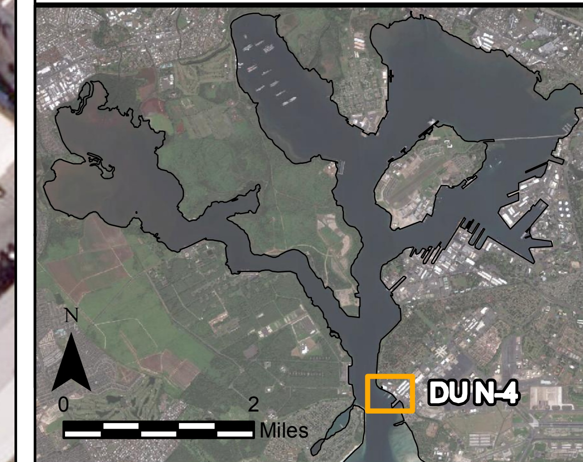
LOCATION MAP



LEGEND

- 2009 and 2012 Sediment Sampling Location
- 2017 Sediment Sampling Location

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for ENR
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy

Refined Remedy Implementation Area

- ENR Implementation Area
- MNR Implementation Area
- Remnant Area Designated for MNR

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. ENR enhanced natural recovery
   MNR monitored natural recovery

N

0 100 200 400 Feet

Figure F-10
DU N-4 Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

NOTES

1. Map projection: Hawaii State Plane Zone 3, unit feet, NAD83 datum.

Figure F-11
DU E-2 Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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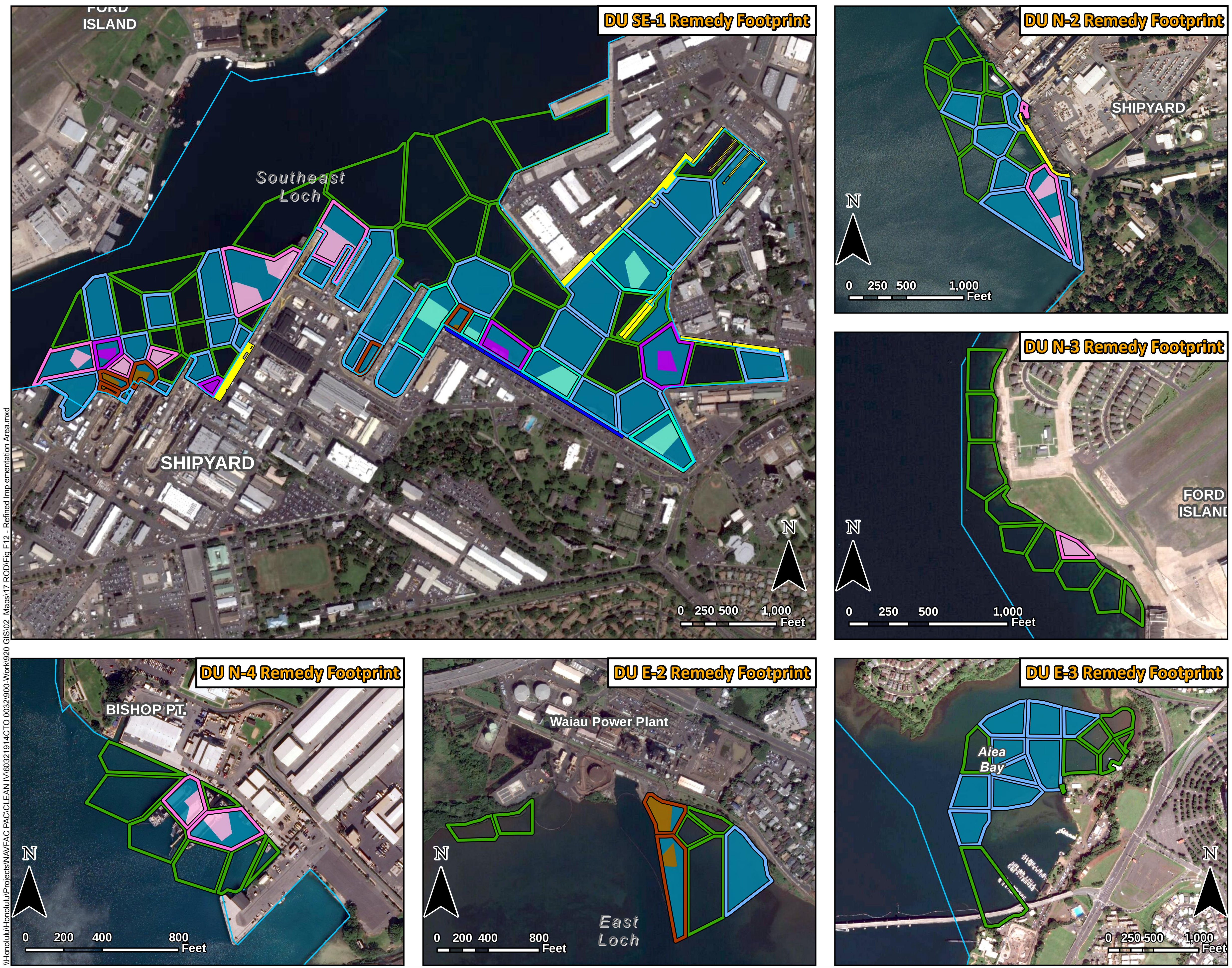
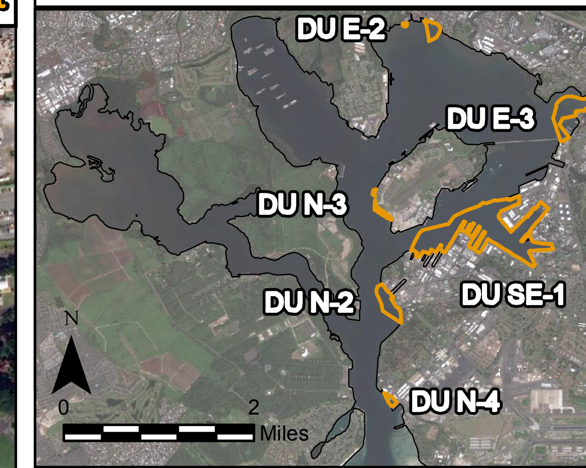


LOCATION MAP



LEGEND

- Maintenance Dredging Footprint

FS (DON 2015) DU Sub-Area Footprint and Designated Remedy

- Sub-Area Designated for Dredging
- Sub-Area Designated for ENR
- Sub-Area Designated for ENR +
- Sub-Area Designated for MNR +
- Sub-Area Designated for MNR
- Sub-Area Designated for No Remedy
- Under-pier AC Treatment Area
- Under-pier MNR Area

Refined Remedy Implementation Area

- Dredging Implementation Area
- ENR Implementation Area
- ENR + AC Implementation Area
- MNR + AC Implementation Area
- MNR Implementation Area

NOTES

1. Basemap source: USGS Earthdata.
2. Map projection: Hawaii State Plane Zone 3, NAD83 (unit: feet).
3. AC in-situ activated carbon treatment.
   ENR enhanced natural recovery
   ENR+AC enhanced natural recovery + AC treatment
   MNR monitored natural recovery
   MNR+AC monitored natural recovery + AC treatment

Figure F-12
Refined Remedy Implementation Area
Pearl Harbor Sediment ROD
PHNC National Priorities List Site
JBPHH, Oahu, Hawaii

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